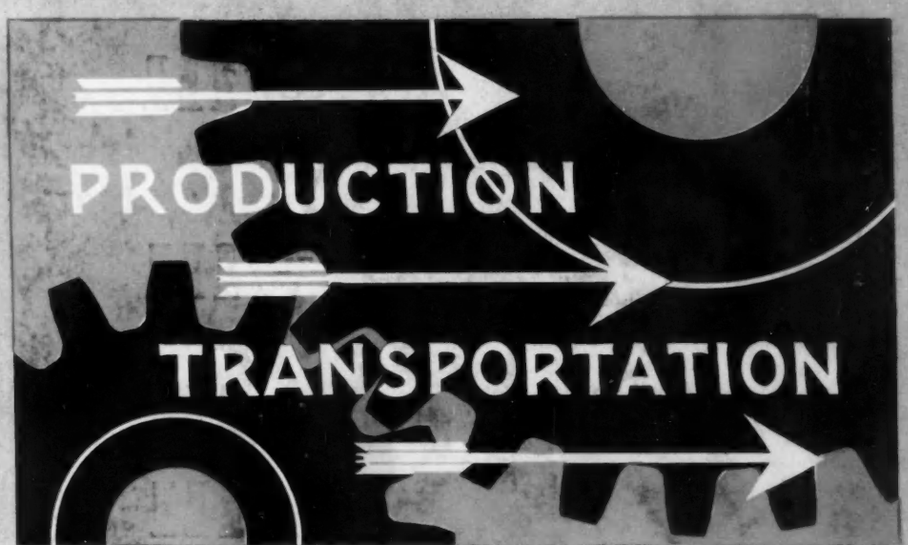
S·A·E JOURNAL



NOVEMBER 1930

The day is coming when Hydraulic Shock Absorbers–

will permit a non-jiggle, uninterrupted, smooth float over all roads of boulevard quality.

will properly support the car body against downward sweeps and bottoming.

will not cause vicious up-bumps to be transmitted to the car body.

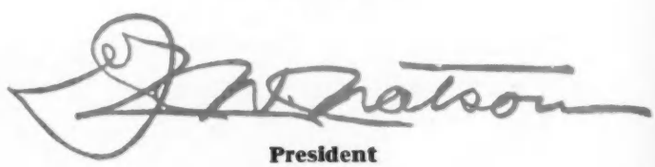
will properly control all pitching, bobbing, throwing and other disastrous effects of rebound forces.

will change but imperceptibly from Summer to Winter.

will be silent in action.

will keep their oil inside to do the work instead of outside to make a mess.

John Warren Watson Company
Philadelphia, Pa.



President

S. A. E. JOURNAL

Published by the SOCIETY OF AUTOMOTIVE ENGINEERS, INC., 29 *W. 39th St., New York*
Cable Address: AUTOENG *Telephone:* LONGACRE 7170

EDWARD P. WARNER, *President* JOHN A. C. WARNER, *Secretary* C. B. WHITTELSEY, JR., *Treasurer*

Vol. XXVII November, 1930 No. 5

CONTENTS

General Design and Research

Automotive Research—Evaluation Tests for Rubber Vibration-Insulators—Franz D. Abbott 600
Standardization Progress 605
Notes and Reviews 628
News of Section Meetings:
Baltimore 518
Buffalo 623
Chicago 619
Dayton 623
Metropolitan 621
New England 526
Northwest 527
Philadelphia 622
Southern California 525
St. Louis 619
Washington 623

Production Engineering

Production Meeting Wins Approval 499
New Developments in Machining Aluminum and Its Alloys—R. L. Templin 548
Wear and Tolerances on Gages—E. J. Bryant 553
The Future of Tungsten Carbide as a Cutting Tool—William H. McCoy 557
Production Activities Considered 617
News of Section Meetings:
Cleveland 520
Indiana 522

Transportation Engineering

Operation and Maintenance Featured 511
Motor-Vehicle Performance Indicating and Recording Devices—Carl W. Stocks 529
Economic Motor-Transport Instruction — Prof. James W. Trimmer 541
Motorcoaches Designed and Built by an Operator —Dwight E. Austin 544
Driver-Training for Maintenance Cost-Reduction—J. S. Lowe 591
Drivers Need Traffic Control 606
News of Section Meetings:
Baltimore 524
Oregon 521

Aeronautic Engineering

Airplane-Spin Symposium—Lieut. Carl Brown Harper, Temple N. Joyce, Paul Hovgard, Garland P. Peed, Jr., Harry A. Sutton and Fred E. Weick 560
Safety and Serviceability in Primary Gliders—William J. Perfield 583
Aircraft-Engine Design for Low Cost—Edward D. Herrick 597
News of Section Meetings:
Northern California 523
Pittsburgh 620
Syracuse 522
Wichita 623

Motorboat Engineering

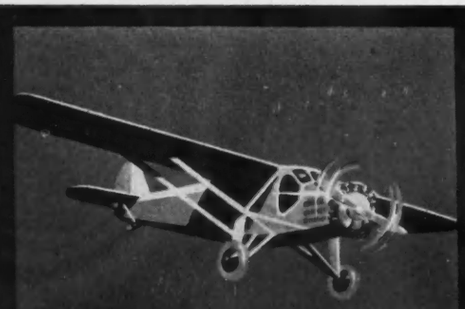
News of Section Meetings:
Canadian 527
Milwaukee 618

News of the Society

News of the Sections 518
Chronicle and Comment 528
Sixth International Road Congress 609
Annual Dinner and Annual Meeting Plans 616
Obituary 616
Council Approves Budget 617
Man Captured! 624
Personal Notes of the Members 625
Applicants Qualified 626
Applicants for Membership 627

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

WYMAN-GORDON



IN THE AIR
TODAY
AS ON THE
HIGHWAYS
FOR THE PAST
30 YEARS

AVIATION FORGINGS

THE CRANKSHAFT MAKERS

WORCESTER, MASS., HARVEY, ILL.

Ninth National Meeting Has Active Support of Officials and Sustained Discussion—Tungsten Carbide the Subject at Opening Session

MEASURED by the attendance at the various technical sessions, the Ninth National Production Meeting must have been twice as good as any of its predecessors. Although the registered attendance at the meeting, which was held in the Book-Cadillac Hotel in Detroit, Oct. 7 and 8, was not as large as at some of the previous meetings, each of the individual sessions was exceptionally well filled. The average in attendance of scheduled chairmen and speakers was 100 per cent; and discussion, both written and oral, directly expressed and indirectly indicated the excellence of the papers presented and the wide interest taken in them.

Further indications of the importance of the meeting are the facts that the chairmen of the sessions were the president of one prominent automobile manufacturing concern, the vice-president of one of the large-production companies and the Vice-President of the Society representing its Production Activity, and that the vice-president of the General Motors Corp. was the leading speaker at the Production Dinner.

Three day-time sessions were attended by production men in numbers larger than the average attendance at the technical sessions of the Annual and Semi-Annual Meetings of the Society. Several motorcoaches were required for transportation to the two manufacturing establishments to which visits were arranged; and the 540 who attended the Production Dinner, arranged by the Detroit Section, filled the ballroom and overflowed to several tables in the balcony.

Commendable was the absolute freedom of all the papers from anything suggesting selling talk. The paper on tungsten carbide was written by a representative of a user, and the papers having to do with products manufactured by firms with which the authors are connected contained absolutely no reference to specific products, being concerned entirely with general questions that would apply as well to the products of other manufacturers. Even the discussion presented contained virtually none of the kind of talk that is characteristic of the men whose chief interest is in sales reports.

Tungsten Carbide and Aluminum

Nearly 100 persons were present when General Manager John A. C. Warner called the opening session to order at 9:45 Tuesday morning, Oct. 7. Several more came in later, so the attendance was well over 100. In opening the session, Mr. Warner gave unstinted credit to those who had done the arduous production work of making the arrangements and the preparations for the meeting, giving special credit to John Younger, Vice-President of the Society in charge of the Production Activity; Joseph Geschelin, Chairman of the Production Meetings Committee; and R. S. Burnett, representative of the Society staff. Each of these men was introduced to the meeting and applauded. Mr. Warner also read the names of the score or more members of the Production Activity Committee, the seven members of the Production Meetings Committee and the 15 leading production executives of the automobile industry in addition who were named as sponsors of the meeting.

Introduced by Mr. Warner as Chairman of the session, J. A. Bohannon, president of the Peerless Motor Car Corp., welcomed the opportunity to take part in the meeting and to express his appreciation of the work of automobile engineers. He referred to the introduction of the electric starter as the fundamental device which changed the automobile from a novelty to an accepted instrument of transportation, and to the introduction of balloon tires and four-wheel brakes as providing the impetus that revived the industry after its halt at the refueling station in 1921 by making obsolete all the cars that had been built previously. Mr. Bohannon said that he looks to the future with confidence in engineering development.

Technique of Machining Aluminum

Aluminum was referred to by the Chairman, in introducing the author of the first paper, as a material that will play a large part in the future development of motor-cars by increasing the ratio of power to weight. The paper was by R. L. Templin, chief engineer

Meetings Calendar

National Meetings of the Society

Annual Dinner—Jan. 8

Hotel Pennsylvania, New York City

Annual Meeting—Jan. 19 to 23

Book-Cadillac Hotel, Detroit

November Section Meetings

Baltimore Section—Nov. 19

Lord Baltimore Hotel; Dinner 6:30 P.M.
Subject—Special Service Equipment

Buffalo Section—Nov. 12

Hotel Statler; Dinner 6:30 P.M.
Highway Transportation—Pierre Schon, General Motors Truck Co.

Canadian Section—Nov. 19

Royal York Hotel, Toronto; Dinner 6:30 P.M.
Address by H. T. Woolson, Chief Engineer, Chrysler Corp.

Chicago Section—Nov. 6

Hotel Sherman; Dinner 6:30 P.M.; Entertainment
Subject—Power Units

Cleveland Section—Nov. 17

Hotel Statler; Dinner 6:30 P.M.; Entertainment
Lead-Base Lubricants—J. A. Edwards, Director of Engineering, Jesco Lubricating Co.
Observations on Testing Lubricants—F. Wooler, Chief Engineer, Timken Roller Bearing Co.

Detroit Section—Nov. 10

Book-Cadillac Hotel; Dinner 6:30 P.M.; Harold H. Emmons, Toastmaster
Aviation in Europe and United States—J. H. Doolittle

Indiana Section—Nov. 12

Indianapolis
Subject—Highway and Street Traffic

Metropolitan Section—Nov. 19

A.W.A. Building, New York City; Dinner 6:30 P.M.
What Engineering Has Done for the Garage—M. A. Kent, President, and Sidney Dresser, Assistant to President, Kent Garage Companies; and Con W. Willemse, formerly Captain, Police Department of New York City
Followed by an inspection trip through the Kent System's new Columbus Circle unit at 61st Street, near Broadway

Milwaukee Section—Nov. 4

Milwaukee Athletic Club
Airplanes of the Future—William B. Stout

New England Section—Nov. 5

Kenmore Hotel, Boston; Dinner 6:30 P.M.
American Gearsets for Passenger Cars—Herbert Chase, Associate Editor, *Product Engineering* and *American Machinist*

Northern California Section—Nov. 20

Richmond, Calif.
Inspection trip through Richmond Refinery of Standard Oil Co. of California, followed by dinner, entertainment and a technical session
The Mechanism of Journal-Bearing Lubrication—George L. Neely, Standard Oil Co. of California
Significance of the A.S.T.M. Distillation Test for Gasoline—J. R. MacGregor, Standard Oil Co. of California

Northwest Section—Nov. 14

Engineers Club, Seattle, Wash.
Subject—Diesel Engines

Oregon Section—Nov. 13

Multnomah Hotel, Portland
Fundamentals of Operating Cost-Systems—Edward Dagner, Fageol Motor Sales Co.
Scale, Rust and Corrosion in Cooling Systems of Trucks and Motor-Cars—Valentine Gephart, President, The Valentine Co.

Philadelphia Section—Nov. 12

Philadelphia Automobile Association Rooms; Dinner 6:30 P.M.
Modern Transmissions—Herbert Chase, Associate Editor, *Product Engineering* and *American Machinist*
The subject of Free Wheeling will be discussed

Pittsburgh Section—No Meeting

St. Louis Section—Nov. 4

Engineers Club
Motorcoach Maintenance—J. Conniff, General Manager, People's Bus Co. of St. Louis

Southern California Section—Nov. 21

City Club, Los Angeles; Dinner 6:30 P.M.
Subject—Ignition; Various Types of Aircraft Magnetos

Syracuse Section—Nov. 4

Hotel Syracuse; Dinner 6:30 P.M.
Taking Off From and Landing on Airplane Carriers—Lieut. L. D. Webb, Bureau of Aeronautics, United States Navy Department

Wichita Section—Nov. 13

Green Parrot Inn; Home-Style Dinner 6:30 P.M.
Symposium on Landing Gears—John R. Cautley, Bendix Brake Co.

of tests of the Aluminum Co. of America, located at New Kensington, Pa., upon the subject of New Developments in Machining Aluminum and Its Alloys. In it Mr. Templin emphasized the importance of using cutting-tool forms and cutting speeds in machining aluminum that resemble those used for cutting hard wood about as nearly as the more familiar machine-shop tools and speeds. Tungsten-carbide tools were said to be necessary for the commercial machining of the high-silicon alloys that have been developed to give a relatively low coefficient of thermal expansion. Mr. Templin's paper is printed in full in this issue of the S.A.E. JOURNAL, beginning on p. 548.

Prof. John Younger opened the discussion by asking if improperly ground tools are not being used for machining aluminum. Mr. Templin replied in the affirmative. He said that his organization sometimes receives complaints in regard to machining aluminum from manufacturers who report that all their tools are ground according to the recommendations of the manufacturers of the metal. In every case of this sort which he recalls, they find that the actual workman does not believe "all that stuff" and follows his own ideas. Such occurrences are not so common in the automotive industry as in other commercial fields.

Forged pistons of high-silicon aluminum-alloy are now being made for radial aircraft engines, Mr. Templin revealed, and the only satisfactory way that has been found to machine these pistons is with cemented-tungsten-carbide tools that are ground as nearly as possible according to the shapes that are indicated in the author's paper. Very satisfactory results are obtained with such tools.

Threading, tapping and reaming aluminum was the subject of a question asked by N. P. Petersen, works manager of the Canadian Acme Screw & Gear, Ltd. Mr. Templin recommended the use of spiral-fluted taps, preferably of high-speed steel. These should be ground with greater clearance at the back of the lands than is found in commercial taps if they are to be backed out of the work. Taps of larger size work well if a rake can be ground on the chasers, as can be done with the tools for threading-machines of several makes. Lard-oil is recommended as the best lubricant, and a mixture of kerosene and lard-oil can be substituted for economy if fire-hazard rules do not prohibit it. Soluble cutting-oil can also be used, mixed a little thicker than for machining steel.

Answering a question by A. H. Lyon, chief engineer of the Ingersoll Milling Machine Co., Mr. Templin said that one of the milling-cutters shown in the paper caused some trouble by the chips filling the space between the tool bits. Additional room for chips is provided in the other cutter shown. Definite rules could not be given for feeds and cutting speeds.

Two Years of New Tool Material

For a study of tungsten-carbide tools, the committee did not turn to one of the manufacturers of the material, but to William H. McCoy, manager of the research experimental production machine-shop of the General Motors Corp. While free from the handicap of commercial prejudice, Mr. McCoy knows the subject both backward and forward; backward, because of the part he has played in such use of the material as has been made in the plants of the General Motors group since 1928, and forward, because of his vision of the course which development must take to better adapt the cemented material to various classes of work. He believes that several varieties will be adapted to various jobs, just as different sorts of tool steel are most suitable for various purposes. Mr. McCoy's paper also is printed in full in this issue of the S.A.E. JOURNAL, beginning on p. 557.

The discussion of Mr. McCoy's paper began with a written contribution from Roger D. Prosser, of Thomas Prosser & Son, importers of the material. Mr. Prosser congratulated Mr. McCoy on the forceful way in which he had shown the savings that have been made by the use of tungsten-carbide tools and remarked that considerably greater savings might have been possible. It may be assumed that the speeds used in many cases were the maximum of which the machine-tools were capable, and it is probable that higher speeds could have been used in many cases with greater savings. Particularly in machining cast iron, Mr. Prosser said that the speeds are well below those which

SOME OF THOSE WHO TOOK PART IN THE SESSION ON MACHINING ALUMINUM AND ON TUNGSTEN-CARBIDE TOOLS

W. H. McCoy, of the General Motors Corp., Who Presented a Paper on the Development of Tungsten Carbide as a Cutting Tool.

J. A. Bohannon, President of the Peerless Motor Car Co., Chairman of the First Session.

W. H. Graves, Chief Metallurgist of the Packard Motor Car Co., a Discusser.

Roger D. Prosser, of Thomas Prosser & Son, Who Submitted Written Discussion on Mr. McCoy's Paper.

W. G. R. Robbins, of the Carboloy Co., Who Contributed Oral Discussion on Tungsten-Carbide Cutting Tools.

can be used safely with the tools he sponsors. He says that the feed is an important factor and the best results can generally be obtained by operating at high speeds with cuts no greater than are customary with high-speed-steel tools.

Testifying to the durability of the tools, Mr. Prosser presented a photograph showing a machine, operating on a bronze part, which has been working every day for more than six months without removing the tools from the machine for regrinding. High-speed-steel tools on the same operation had to be reground several times each day.

Toughness Sacrificed for Hardness

Extreme hardness and great toughness do not go hand in hand, so Mr. Prosser believes that it is not reasonable to expect toughness in these tools. When tools are designed and used with due regard to the brittleness of the material, no difficulty need be encountered with intermittent cuts. Many of the early failures of the material were due to the use of tool tips that were too thin to conduct the heat away from the cutting edge. Tool forms introduced by Taylor in 1906 are still good, with some modifications in angles for tungsten carbide. A slight change in angle sometimes will result in a great reduction or the entire elimination of the building-up which is sometimes observed on the cutting edge, and the clearance under the cutting edge should be kept as small as possible, usually about 4 deg., to give the maximum support. A list of recommended tool angles was given for various grades of steel, cast-iron, bronze, brass and aluminum alloys, which include slight modifications that have been made recently in the recommendations as presented by Mr. Prosser in previous papers.

Four grades of tungsten carbide are being provided now by the Krupp concern for tools for various purposes, Mr. Prosser revealed, but he believes that the number of grades should not be multiplied too freely. He hopes for increased toughness, but says that this must not be obtained at the expense of a sacrifice in hardness.

In closing, Mr. Prosser emphasized the statement that tungsten carbide is not a cure-all for machining troubles. While some tough jobs can be made easy with this material, the biggest savings are found in ordinary high-production jobs on which the increased cutting speed and the increased tool life between grinds are important.

Intermittent Cuts Can Be Made

Intermittent cuts was the subject introduced by W. W. Nichols, vice-president of the D. P. Brown Co., who asked if the impression of uncertainty as to intermittent cuts is not due to a failure to provide amply large tool-shanks. He asked if square billets of steel had not been machined with tungsten-carbide tools in the Krupp factory. Mr. McCoy confirmed this and said that intermittent cuts are now being made without difficulty in one of the General Motors divisions. Success has been achieved by providing tools having heavier shanks and tips and by preventing back-lash in the feed.

Further confirmation in regard to intermittent cuts was given by W. E. Smith, manager of the Widia department of the Wesson Sales Co., of Detroit, who said that there is difficulty in providing shanks large enough for the purpose of American machine-tools. He cited experience in machining armor plate of a sort that had never before been machined. Shanks 2½ in. square were tried first, and they failed. The Leviathan of a shank which did the job successfully made the shank first tried look like a rowboat.

In answer partly to various questions from the floor and partly to Mr. Prosser's discussion, Mr. McCoy said that he would not hesitate to recommend tungsten-carbide tools in the initial tooling for an operation on gray iron or aluminum in which a fine feed and fine finish are required. For operations that involve intermittent cuts or where production must be started in a hurry, he would prefer to start with tools of high-speed steel before trying the tungsten carbide. Difficult jobs may require some experimenting with tool angles and other variables, but such problems can be solved now much more quickly than when the tungsten-carbide tools were more of a novelty.

Rigidity and freedom from back-lash in the tool support and closely fitted or adjusted bearings, whether plain or antifriction, are among the principal

CHAIRMAN AND SPEAKERS AT THE PRODUCTION-ECONOMICS SESSION

John Younger, Vice-President of the Society, Representing Production Engineering, Who Presided as Chairman

Paul N. Lehoczky, of Ohio State University, Who Presented a Paper on Effect of Time on Production Cost

O. B. Jones, of the Detroit School of Applied Science, Who Gave a Paper on the Tool Engineer's Place in Production

Joseph Geschelin, Associate Engineering Editor of *Automotive Industries*, a Discusser

Erik Oberg, Editor of *Machinery*, Who Discussed the Question of Economic Lots

requirements to make machine-tools suitable for use with tungsten-carbide tools. Mr. McCoy is not in favor of plunging into exceedingly high speeds. Probably the tool will pay for itself if the speed is 300 ft. per min. Speeds of 600 ft. per min. are being used in some General Motors operations on cast iron, but it seems preferable to guard against danger of failures which might create or increase a prejudice against the material.

Mr. Templin welcomed the information in Mr. McCoy's paper as supporting his plea for suitable tool-angles for cutting aluminum; and W. G. R. Robbins, of the Carboloy Co., confirmed the economy of the new tools when used at cutting speeds no higher than can be obtained on the machine-tools now in service. Mr. Smith cited a number of instances in which large economies have been made because of less frequent tool changes. Milling-cutters were said by Mr. Robbins to be among the most promising applications of tools tipped with tungsten carbide.

Regarding the horsepower required for tungsten-carbide tools, one instance was cited in which a 30-hp. motor was said to be necessary in place of one of 7½ hp., but Mr. Smith said that tests by several experimenters have shown that the horsepower requirements do not increase in any such ratio as that.

Educating the operators is one of the biggest problems in connection with cemented tungsten-carbide, according to Vernon E. Walters, general master mechanic of the Oakland Motor Car Co. Some failures have been due to operators who have broken the tools intentionally. He cited causes of several other failures. He also told of an occasion when the only malleable-iron castings available in the axle department were too hard to be machined except with tungsten carbide. Faced with the choice of using the tools or seeing the plant shut down, the operators used the material successfully. The emergency passed, the operators would not part with the tungsten-carbide tools.

Others who took part in the discussion were W. H. Graves, Packard metallurgist; E. R. Smith, vice-president and general manager of the Seneca Falls Machine Co.; Charles J. Oesterlein, vice-president of the Oesterlein Machine Co.; T. J. Litle, Past-President of the Society; and Joseph Geschelin, of *Automotive Industries*.

Economics of Time

Time as a Factor in Cost—Who and How in Training Production Engineers

PROF. John Younger, Vice-President of the Society in charge of the Production Activity and editor of *Automotive Abstracts*, was Chairman of the Tuesday afternoon session, which was designated as the Economics Session. Mr. Younger said that production engineering has two distinct problems: first, the technical one of the tools and methods for doing the work; and, second, the economic problem of which tool and method is the cheaper to use. He believes that the latter problem is assuming increasing importance.

So great is the importance of the economic phases of production and selling and statistical information, said Mr. Younger, that it may be advisable to consider establishing an Economics Division among the Activities of the Society. With this preface, Paul Lehoczky was introduced as a man who is devoting much attention to the economic problems of industry.

Mr. Lehoczky is connected with the department of industrial engineering of Ohio State University, as also is Mr. Younger, and his paper was upon The Effect of Time on Production Cost. He said that economies in materials have offered the most obvious chance for saving, which is one of the chief aims of the production man. Such savings may result either directly from lower costs or indirectly because of better qualities. A second noteworthy method for cutting costs involves the factor of time. Decreasing the time required for fabricating operations decreases the capital investment. Time is the basis for a group of efforts of a relatively new type that involve economic lot sizes for manufacturing or purchasing, seasonal production and seasonal sales. Such analyses aid in finding how the lowest possible cost can be obtained. Several fundamental factors are involved and a change in any one of them will cause a change in the lowest-cost conditions.

Relatively Simple Formulas Developed

Considering only capital and set-up cost, formulas were presented representing the cost of the product with one set-up for continuous production, for two lots per year, and a general formula for any number of lots. This last formula is differentiated to find the minimum of the curve it represents. Following this, a more general formula was developed in which additional factors wers taken into consideration. Specific examples were worked out according to this formula, and a curve was presented to represent the variation in cost in a given case according to the number of lots produced per year.

An analysis of this type was said to be applicable whenever production capacity is greater than the output required, particularly if the equipment can be used for other purposes than that under immediate consideration; in purchasing, when the time factor must be balanced against discounts or quantity prices; and in the minor items of supplies, tools and small parts. The percentage of saving often is greater in the items involving smaller amounts. The formulas will differ for different cases, but the principle of balancing the opposing factors is the same.

Automotive production engineers have been so busy during the last few years that they have thought only of continuous production as the most economic method, said A. R. Fors, planning manager of the Continental Motors Corp., in opening the discussion. He himself has been in the habit of seeking the lowest cost with little regard to investment. Present conditions, he believes, will cause engineers to change their way of thinking, to the benefit of all.

Formulas Have Proved Serviceable

Application of formulas of the sort advocated by Mr. Lehoczky was reported by K. W. Stillman, of *The Business Week*, who said that when he was in charge of a department of the General Electric Co. he worked out a formula of the sort that had to do with material control. Thousands of items were involved. An approximate formula was developed and embodied in an alignment chart by means of which an economic-lot quantity could be determined without computation. Production rate, cost of set-up, cost of materials, interest rate and perhaps one or two other factors were considered.

Application of such a formula in the publishing business was cited by Erik Oberg, of The Industrial Press, as an indication of the general application of the principle. By this means it is possible to determine the economic number of copies of a book to be printed at one time. Chairman Younger said that he has found an increasingly large number of firms to be giving consideration to formulas to guide them in planning production lots.

Questions by Mr. Oesterlein and others brought from Mr. Lehoczky the statement that the effect of seasonal sales would have to be worked out according to the curve of sales for the particular case. Interest charge is a most important factor, applying both to the capital involved and to the storage and handling costs. Obsolescence works in the same direction as interest, and the set-up charge is one of the items that must be balanced against it.

Shop Air Nourishes Tool Engineers

Selecting and training men for work as tool engineers in mass production was the subject considered in the paper

by O. B. Jones, of the Detroit School of Applied Science. Anticipating the preparation of this paper, Mr. Jones wrote to a number of leading engineers in the automotive industry to ask their opinions on certain questions. He reported a singular lack of agreement among the replies received. Recounting the routine that is followed in the designing of new parts and planning for their production, the author proceeded to a brief survey of machine equipment available and said that the tool engineer must have a thorough knowledge of the machines available and their capabilities as a basis for his work.

Experience in the tool-designing department of an automobile-manufacturing organization he considers the best way to learn the principles of mass production. The tool engineer must supervise the designing of all tools to equip the machines in the plant for the parts to be manufactured, avoiding the use of special machines which might be a total loss because of some slight change in the design of the product. It is not necessary that he should be a toolmaker or able to operate all the tools, but he must be of a mechanical turn of mind and able to grasp the purpose, construction and method of operation of any machine.

Drafting is an essential basis of the tool engineer's training, which should include a thorough grounding in mathematics up to and including trigonometry and the fundamentals of mechanics and metallurgy. The calculation of costs is an important essential, as the engineer must ever be balancing the initial cost of machinery and equipment against the time and money it will save.

Measuring the Tool Engineer's Job

A regular training in mechanical engineering provides a splendid foundation for specialized training as a tool engineer, continued Mr. Jones, but such training is not essential and very few graduate mechanical engineers become tool designers and tool engineers. Problems relating to the design of tools for mass production are not fully covered in the institutions of higher learning, and the atmosphere of the plant seems essential to the thorough understanding of the subject. The cooperative method of training seems ideal for the purpose.

Executive capacity, energy, tact, aggressiveness and mental balance are required by the tool engineer, whose big job Mr. Jones considers to be that of keeping the foremen sold on his ideas. Willingness to accept suggestions and concede unimportant points will prove a help when it is necessary to put over a big idea.

The magnitude of the savings that can be effected is indicated by the estimated number of 30,000,000,000 operations involved in the annual production of 500,000 cars. A saving of one second on each operation would amount to approximately $7,000,000 per year or $14 per car.

More tool engineers will be needed in the future, and Mr. Jones suggests cooperation between educators and manufacturers in planning and developing a course of study and method of training that will be as efficient as the plans of production that the production engineers have devised.

Economic Problems Are Created

Special machines are on the increase, rather than the decline, in the opinion of L. A. Blackburn, of the Oakland Motor Car Co., who opened the discussion. Ordinarily, a cylinder-block line will not change for several years, and nearly all of the machinery in the cylinder line is special. Mr. Blackburn approved the idea of developing a plan for training tool engineers and expressed interest in some of the personal problems that are being created. Tool designers are made into floaters by the conditions which require the tool-design department to work 12 to 14 hr. a day for about three months and then go through the rest of the year with one-third of the working force. He is also interested in the welfare of the individual workers whose jobs are taken by improved machinery.

Mr. Jones said that he does not regard a cylinder-lapping machine as a special machine, because it can be adapted to a new design of engine. The special machine to be avoided is the one that is made for an individual operation and must be discarded when that operation is obsolete. Apropos of the labor question, he said that tool engineers seem to have done their work so well that more goods can be produced in three months than the salesmen can sell in a year.

Training in economics, psychology and the human side of engineering, such as is given in the courses in industrial engineering at some colleges, was advocated by Chairman Younger as a groundwork for the tool engineer.

Transporting and Gaging Parts

Conveyors and Where To Use Them—Gages and When To Scrap Them

GORDON LEFEBVRE, vice-president of the Oakland Motor Car Co., served as chairman of the session on the morning of Oct. 8, and proceeded directly to the business in hand by introducing J. H. Hough, of the Mathews Conveyor Co., to present his paper on Conveyors in the Automotive Industry.

Beginning with a division of the various types of conveyor into three classes, Mr. Hough indicated briefly the construction and application of overhead conveyors, general-type conveyors and trucks. The familiar chain-trolley conveyor, monorail and crane comprise the overhead conveyor classification. Conveyors of the general type include gravity rollers, belts, aprons, pusher-bar elevators, tray elevators, electric hoists, drag chains, spirals and mechanical spiral lifts and descenders.

Drag chains running at very low speeds are commonly used for assembly lines, according to Mr. Hough, and the power required is very small, in spite of high friction-loads, because of the slow speed. Roller conveyors are used commonly for moving parts in automotive plants.

Tray elevators, consisting of two parallel chains carrying trays, and electric hoists are used for the same general purpose. The electric hoists require less floor space but more time between units to be moved.

Rotating spirals of different sorts are used for lowering and transporting materials in cans or bags in some industries. These and other types of equipment may offer suggestions for use in the automotive industry. Uses of the various classes of tractors, lift trucks and hand trucks were described.

Formulas for Estimating Conveyor Profits

Formulas were presented by Mr. Hough to show the maximum investment that would be justified for a mechanical-handling system under given conditions and the profit that would accrue from the use of the equipment. These are formulas that are adaptable to any type of labor-saving equipment, their adaptation to mechanical handling being presented.

In their use, a correct application of the overhead charges is important, and Mr. Hough showed how the question of whether direct or indirect labor is saved affects the total saving made by the equipment. The omission of credit for overhead charges saved is an error that has frequently obscured the issue in making comparisons.

The paper included tables giving approximate costs of various types of conveyor and other handling equipment which may be used in estimating the cost of equipment for certain conditions and determining whether an installation will be profitable. A considerable number of slides were exhibited, show-

ing applications of handling equipment of various types. Most of the equipment shown was in automotive plants, but examples from other industries were included as suggestions for possible automotive-manufacturing applications.

Several conveyor engineers were ready with discussion of the paper, which was opened by D. A. Blair of the Jervis B. Webb Co., with a statement that saving floor space should be considered in calculating the relative savings that are effected.

W. B. Casgrain, of Mechanical Handling Systems, made several additions to the list of conveyor types given by Mr. Hough. Side-pusher lines are used in connection with monorail systems in parts of the line where conditions make it desirable to substitute mechanical for hand power, and sometimes as an independent unit. Chain conveyors similar to the overhead-chain type also are used with direct-pusher or side-pusher connection to dollies or trucks in cases where changes in horizontal direction are required. The side-pusher type makes it possible to start or remove dollies at any point along the line. Mr. Casgrain sees a tendency for power-driven conveyors to displace gravity conveyors in the production machine-shop.

Assembly-line conveyors, according to J. E. McBride, of the Palmer-Bee Co., now are being made on the wheel-and-axle principle, with roller bearings. He cited an instance of a large manufacturer who formerly dragged his chassis over assembly lines 1000 ft. long. The rear axle was sometimes almost sawed in two on the narrow track, 50 hp. was required for each line, and breakdowns were frequent. Substituting roller-bearing equipment eliminated the trouble and made 3-hp. motors ample.

Single overhead-conveyors for enameling equipment have caused defective work because of dirt falling from the track. Substituting two strands spread wide apart and connected by rods or pipes prevents this difficulty. In one plant mentioned rejections were reduced from 50 per cent to 2 per cent in this way. Mr. McBride closed with an impressive list of the advantages resulting from the use of conveyors in manufacturing operations.

PARTICIPANTS IN THE SESSION ON CONVEYORS AND GAGES

J. H. Hough, of the Mathews Conveyor Co., Who Presented a Paper on Conveyors in the Automotive Industry

Gordon Lefebvre, Vice-President of the Oakland Motor Car Co., Chairman of the Session

E. J. Bryant, of the Greenfield Tap & Die Corp., Who Gave a Paper on Wear and Tolerances on Gages

D. A. Blair, of the Jervis B. Webb Co., Who Spoke on the Saving of Floor Space Effected by the Use of Conveyors

W. V. Casgrain, President of Mechanical Handling Systems, Inc., Who Told of Pusher Conveyors

Orrel A. Parker, President of the Parker Wheel Co., and a Councilor of the Society, Who Discussed Mr. Bryant's Paper

Tolerances and Allowances for Gages

Gaging of the work, the subject treated by E. J. Bryant, of the Greenfield Tap & Die Co., made a suitable closing paper for the final technical session of the meeting. Mr. Bryant advocated definite wear tolerances for gages and definite times for inspecting the gages in service. His paper is printed in full in this issue of the S.A.E. JOURNAL, beginning on p. 553.

William J. Outcalt, standards engineer of General Motors Corp., registered the objections of David W. Ovaitt, efficiency engineer of the Buick Motor Co., to the American Standard report on allowances and tolerances for metal fits as shown in Table 3 of Mr. Bryant's paper. The practice represented by this table has been found quite impracticable by the General Motors Corp. for use in its work. This corporation has adopted a substitute table of tolerances for cylindrical holes which has been published and has been adopted by the Chrysler Corp. also. This table of General Motors tolerances was submitted as part of the discussion.

Where Wear Allowances Can Be Made

Written discussion submitted by A. W. Schoof, of the Western Electric Co., was read in his absence by Mr. Geschelin. Mr. Schoof defined three classes of assemblies, according to whether looseness, close fitting or tight fitting is desired, and analyzed the various classes as to how wear allowances on the gages can best be provided. Diagrams were shown to make clear the relations of the various tolerances and allowances for the three classes of fit.

The use of adjustable and indicating gages instead of solid gages is advised wherever possible, to minimize the effects of gage wear, but such gages and the master gages involved also need to be checked. The use of optical projectors is advocated for determining the effect of wear, particularly of thread-gages. Ring thread-gages are undesirable as checks, because it is so difficult to determine their accuracy. The optical flat is another inspection device the more extensive use of which is recommended by Mr. Schoof for determining the accuracy of gages.

Written discussion was received also from W. H. Gourlie, of the gage division of the Pratt & Whitney Co. He called attention to the basic principle

that allowance for wear on gages is possible only because of the ability of the shop to produce work within closer tolerances than are necessary for satisfactory performance of the product. Failure to keep this principle clearly in mind may result in either increasing the cost of the product unduly or allowing the dimensions of the product to come outside the dimensions laid down by the engineering department. An example is given of a part costing $1 each in lots of 2500 and requiring gages costing $50. Reducing the working tolerances from 0.002 in. to 0.0015 in. reduced the cost of gages to $20, with the unexpected result of adding 1 per cent to the cost of the product. The result was a net loss of $220 instead of the expected saving of $30.

Application of tolerance on Not Go plug-gages in the plus direction may be acceptable in some cases, but it is a dangerous proceeding if the product is to be sold and is subject to reinspection by the customer.

Mr. Gourlie added emphasis to Mr. Bryant's comments on cleanliness in connection with gaging, particularly where precision gage-plugs are concerned. The degree of care used affects the life of the plugs, cases on record showing a variation in life between ten years and one week.

Mr. Rundorff, of the Buick Motor Co., made clear the difference between the General Motors system of tolerances and that shown in the American Gage Committee's report by the example of a 1-in. cylindrical hole. He said that the maximum diameter for all classes is basic size plus 0.0005 and that the negative tolerance varies in the six classes established. The minimum size is basic size for class No. 6, and progressively smaller for the other classes. An advantage of this is that it makes it possible to use a standard gage for class No. 6 and pass it on down to the lower classes as the Go portion of the gage becomes worn.

A similar development was found necessary in standardizing bushings, drills and reamers. The plan is said to give the maximum life of gages and other perishable tools.

Distortion Makes Gaging Difficult

Distortion of the work was a subject introduced by Orrel A. Parker, of the Parker Wheel Co. Bearing seats in a hub, for instance, may be machined within very close tolerances and found to be outside the tolerances a few hours later because of relieving the casting strains, particularly if outside cuts are taken near the same point. Sometimes the result is a bore so elliptical that the Go gage will not enter the short diameter and at the same time the Not Go gage will enter across the long diameter. The application across the long diameter of a clamp having a small wing-nut will restore the circular form, as will pressing the bearing raceway into place. A similar condition is sometimes caused by chucking; the gages will pass the part while it is being held in the chuck, but not after it has been removed from the machine.

In closing the discussion, Mr. Bryant said that there have been two classes of thought ever since the question of standardizing limits has been considered. One of these schools favors standard-hole tolerances and the other favors standard-shaft tolerances. He said that the standard-shaft basis is more desirable in some industries in which the production is in small lots and interchangeable tools are desirable. He believes that there is a field for both practices and doubts if either could be made universal.

Gages, after all, are only a means to the end of producing the work according to requirements. If distortion complicates the problem, that should be taken into account in the gaging. Ordinary methods of gaging may not show when a supposedly cylindrical part is not exactly round. For instance, a heart-shaped cam is far from being round and yet its diameter is the same at every point. Wires used in measuring thread-gages sometimes are not cylindrical, and the error is multiplied into an appreciable amount by the angular application.

Wilson Gives Economics to Diners

Tells 540 Present That Imperfect Distribution, Not Excessive Production, Slows up Industry

WEDNESDAY evening, Oct. 8, saw the final act of the Meeting in the Production Dinner, which was staged by the Detroit Section in the grand ballroom of the Book-Cadillac Hotel. The dinner got under way when P. J. Kent, Chairman of the Section, and a score of his assistants marched into the room and took their places at the head table. Very appropriately, every man wore a black machinist's cap, as they filed in and took their places, and most of the time during the evening. Before the proceedings were over, it was apparent that a number of these men had worn such caps many times before and worn them all day.

During the dinner service, a man appeared on the orchestra platform at the end of the room, introduced James Schermerhorn, Jr., in florid terms, the climax of which was "prince of peddlars," and sat down. Then he got up again, said it was great fun to introduce himself and proceeded to introduce the various entertainers who amused the roomful of diners with songs and dances. The Toastmaster later announced that Mr. Schermerhorn is the new editor of the *Detroit Supercharger*, which is appearing in a new dress.

C. E. WILSON, OF THE GENERAL MOTORS CORP.

Who Spoke on Automobile Production and Economic Conditions at the Dinner

Production Pioneers Introduced

After the clatter of dishes was over, Chairman Kent proceeded to introduce the members of the production organization which he had assembled for the evening to settle the big production problems that were left over from the previous sessions. He named and dated the first job that each of the men had in the automobile business, and each of them rose in his black cap and bowed for the applause. First among those introduced was Joseph Geschelin, Chairman of the Production Meetings Committee and associate engineering editor of *Automotive Industries*. He was a draftsman for the Ward Motor Vehicle Co. in 1914, and was assigned to the job of chief draftsman of Phil Kent's imaginary organization. E. V. Rippingille also entered the industry as a draftsman, for the Lorraine-Dietrich organization in France. Because of his recent European experience, he was assigned the job of export manager.

Memories of the spine-cooled Knox car of Springfield, Mass., were recalled when Frank Barnes, works manager

of the Hupmobile Motor Corp., was introduced. He was a repairman for the Knox company in 1906, and the Toastmaster assigned him the job of service man. Arthur R. Fors was introduced as a man who has stayed with the same company. In 1912 he was a tool designer for the Continental Motors Corp., and now he is planning manager for the same company. Foreman of the tool and die shop was the job assigned to him. Another man who has climbed in one company is Robert Waldon, who began on salvage work in 1924 and is now production manager of the Hudson Motor Car Co. Jack A. Callahan was production manager of the Thomas Motor Car Co. in Buffalo in 1912, and now is with the Briggs Mfg. Co. Foreman of the final-assembly line was his job in Kent's organization. K. T. Keller was

P. J. KENT, OF CHRYSLER MOTORS

Chairman of the Detroit Section and Toastmaster at the Production Dinner

assistant foreman in the automobile-engine division of the Westinghouse Machine Co., at East Pittsburgh, when they were building engines for the Chalmers Motor Co. in 1908. He is now general manager of the Chrysler Corp., but for this evening he was reduced in rank to foreman of the engine department.

Passing to the opposite end of the table, Bob Burnett, office contact man for the Production Activities and standards manager of the S.A.E., was introduced as a designer of starting and lighting systems for the Bijur Motor Appliance Co. in 1912. W. R. Strickland, who recently resigned from the Cadillac Motor Car Co., was assistant chief engineer of the Peerless Motor Co. when he first entered the industry. Paul Sauerbrey, vice-president of the Plymouth Motor Car Co., was grinding crankshafts for the Fiat Company at Poughkeepsie, N. Y., in 1906.

Other early beginners were Edward P. Roberts, vice-president of manufacturing of the Packard Motor Car Co., who was superintendent of the plant in Westfield, Mass., where the C. J. Moore car was being made in 1901; and Jack Russell, works manager of the Timken-Detroit Axle Co., who was general foreman of the Garford Automobile Co. in Elyria, Ohio, in 1906. Fred Kroeger, who has succeeded the chief speaker of the evening as president and general manager of the Delco-Remy Corp., entered the industry as research engineer of the Remy Electric Co. in 1913.

Society Officers Have Their Inning

John A. C. Warner was introduced with the request that he say something on the occasion of the first Detroit Section Dinner which he has attended since becoming General Manager of the Society, but he took time only to compliment those who had staged the dinner of the evening. The job assigned him by the Toastmaster was that of lubrication engineer. That was said to have been his first job in the industry and to be his principal job now.

Edward P. Warner, President of the Society, was also called upon to speak and emphasized the importance of bringing together the engineers and research men in all branches of the industry to aid in a better understanding between the various groups of production, designing and research men in their mutual problems.

A few Scotch stories were squeezed out before and after the introduction of John Younger, Vice-President representing Production Engineering, as one of the speakers of the evening. He told about using the visor of a cap like the one he was then wearing as a feeler gage to test the fit between pistons and cylinders. He began as a mechanical observer on Rolls-Royce cars in Glasgow, Scotland, in 1901. Chief inspector was the new job given to him.

Economics is receiving more and more attention in the activities of the Society, said Mr. Younger, and he proposed that the Society consider expanding its activities to include the economics of production and distribution, thus developing an activity which will be of importance to the executives of the industry.

The Path of Wilson's Progress

Starting and lighting systems engaged the first automotive activities of C. E. Wilson, vice-president of the General Motors Corp., who was introduced as the principal speaker of the evening. His first job after graduating from the Carnegie School of Technology in 1909, according to the Toastmaster, was with the Westinghouse

JAMES SCHERMERHORN, JR., EDITOR OF THE *Detroit Supercharger*

Who Introduced the Dinner Entertainers in a Humorous Vein

Electric & Mfg. Co. He was made engineer in charge of Westinghouse automotive equipment in 1913, and was in charge of the development of military radio generators for the same company during the war. In 1909 he became chief engineer of the Remy Electric Co., rising step by step until he was made president of the Delco-Remy Co. when the Dayton Engineering Laboratories were combined with Remy. After bringing this organization to the point where it employed 8000 men, he was last year made successively assistant to the president and then vice-president of the General Motors Corp., and has been said to be the "fellow who runs the General Motors Corp. while Mr. Sloan is playing golf."

Production Features and Trends

After briefly outlining the successive stages of industry from home industries through individually owned factories and corporations to the characteristic American production system of progressive manufacturing of interchangeable parts of good quality and quantity at low cost, the important developments that have contributed to the success of this system he lists as high-speed tool-steel; scientifically designed single-purpose machine-tools; standardized cost-accounting; wage incentive and time study; progressive sequence of operations and assembly; conveyors and material-handling equipment; production and inventory control; jigs, fixtures and special tools; budget control of expense; selection, training and assignment of personnel, and the standardization of parts and operations. The last-mentioned item he explained by showing that, while it

is impossible to make parts absolutely the same for similar lines of cars or units, it usually is possible to make the parts nearly enough alike so that the same factory equipment is available with slight changes of tooling.

EMBARKING FOR INSPECTION OF PLANTS

Looking into the future, Mr. Wilson believes that industrial chemistry will play an increasing part, perhaps by providing new methods of heat-treatment, new methods for rust prevention, new synthetic materials and new kinds of finish. The economics of production will be substituted for opinions and feelings. Increasing use of electrically welded parts as a substitute for machined castings is foreseen.

Industries now are giving increasing attention to the problem of providing more uniform employment to their workers. Production control has had for its object securing the minimum investment in materials and work in process; it may be modified, at the expense of greater inventories, to take up the slack between the production and selling cycles of the business.

Confidence in the future of the automobile business was expressed by Mr. Wilson, who said that the production curve will show a recession every few years, but the automobile is now necessary. To illustrate how necessary, Mr. Wilson told of a conversation, during a previous period of depression, in which a man said that if he had to give up either his automobile or his wife, he would be forced to give up his wife. "Without a car I doubt if I could keep her; and I know that I could never get another wife without a car."

Faulty Distribution Causes Distress

When there are too many automobiles in Detroit, too much coffee in Brazil, too much sugar in Cuba, too much rubber in Java, too much copper in Chile and too much money in the banks, it is hard for Mr. Wilson to understand how that condition can actually be overproduction so long as there are people who really want those things. The real troubles seem to be that the economics of distribution have not kept pace with the economics of production, and that the world does not yet really understand money and finance.

Wealth is in two general forms. One is the accumulated wealth represented by gold, bonds, lands and inventories. The other, which is measured by the same dollar, is capitalized earning power, represented by anticipated wages and other income and utilized in purchasing automobiles and other articles on the installment plan. When anything begins to affect distribution, there is a great shrinkage in the anticipated earning power, and that produces the same result on the Country as famine and pestilence did in previous centuries.

Reference was made by Mr. Wilson to a magazine article by H. G. Wells in which he listed the ten great discoveries in the history of the race. The last two on the list were the discovery of money or finance and the abolition of insurmountable differences with the realization that the world is round, finite and complete. The two great movements that will come next were said to be the scientific development of world economics and of world education. The automotive industry was said by Mr. Wilson to have a hand in working out the overcoming of the formerly insurmountable differences and the development of world economics.

Mr. Wilson closed with the statement that it is not the production men who have "let the Country down," but our brothers who are engaged in finance and distribution.

Production Men Visit Plants

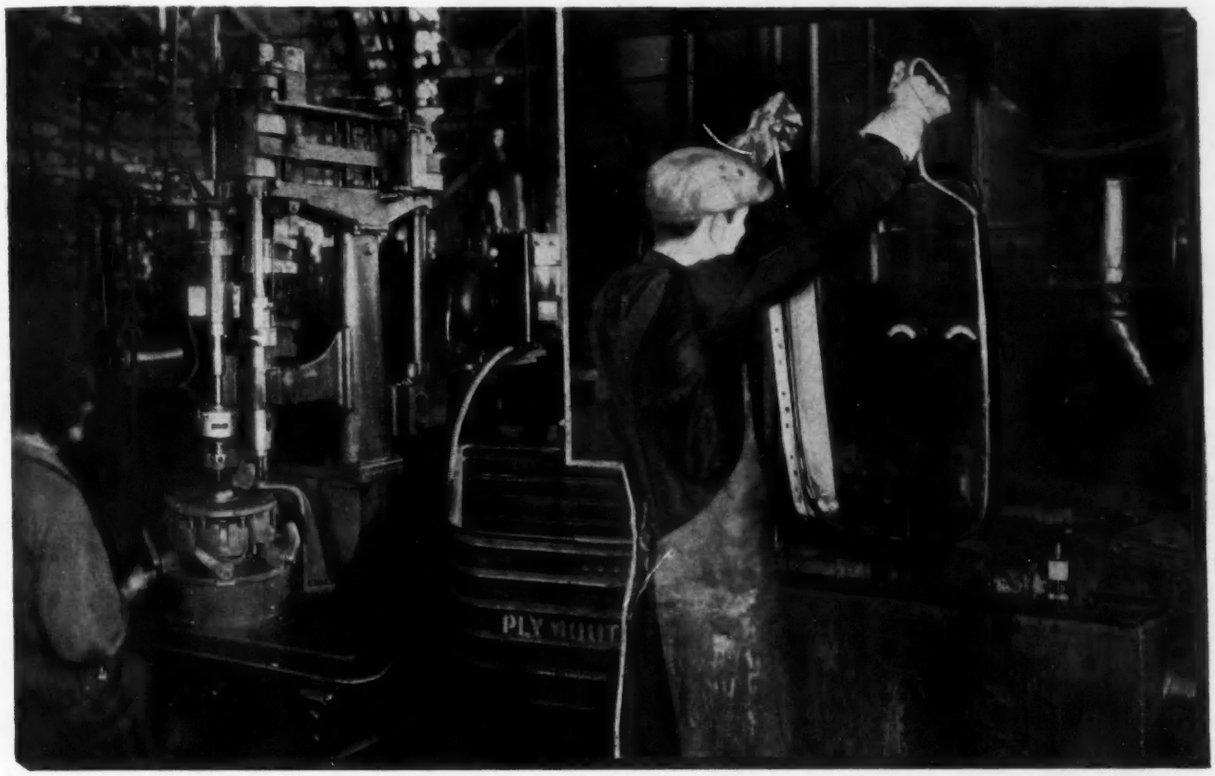
Plymouth Factory and Chevrolet Forge and Spring Plants Inspected by Visiting Members

ON Wednesday afternoon, Oct. 8, a number of attendants at the Production Meeting availed themselves of the opportunities that had been arranged for visiting the Plymouth plant of the Chrysler Corp. and the forge and spring plants of the Chevrolet Motor Co. Three large motorcoaches, provided by the hosts, left the Book-Cadillac Hotel at 1:45, one of them going directly to the Chevrolet plant and the other going first to the Plymouth plant. The visitors at the Plymouth plant were able also to visit the Chrysler plant.

The engineers and their guests were welcomed in the offices and provided with competent guides who showed them through the works in small groups, explaining details of production which were thought to be unique. The great Chrysler plant of steel, concrete and glass, of the familiar saw-tooth-roof design, is admirably laid out for progressive inspection.

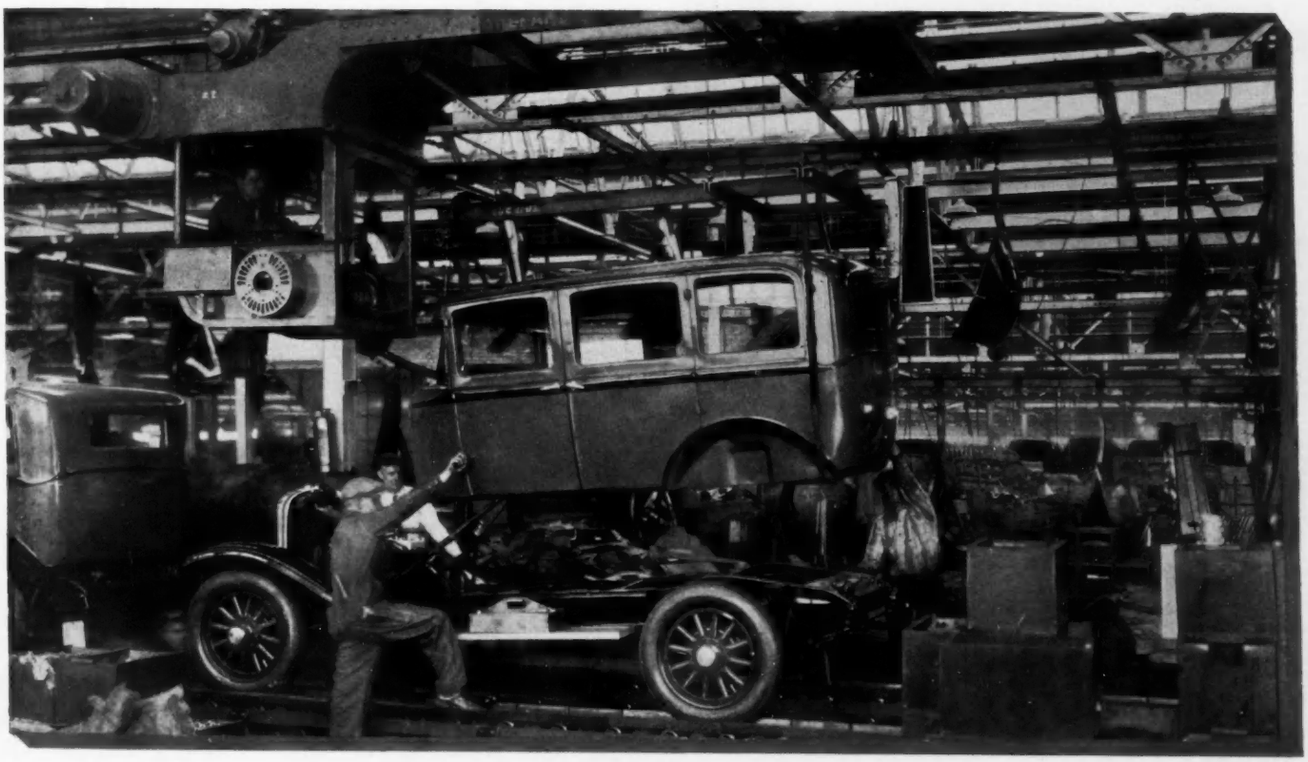
Beginning with raw materials and minor assembly, the visitors were shown some of the outstanding mechanical processes of automotive production: circular milling-machines in which the ends of the cylinders were faced, special lathes and boring mills, ingenious washing machines and spraying machines, and the scores of modern machine-tools which the automotive industry has called into being. There was evidence everywhere of careful planning, a progressive and systematic control of inventory, and an efficient scheme of overhead and knee-high conveyors. Component parts such as frames arrived in orderly sequence, pendant from an overhead conveyor. Engine blocks and other heavy parts slid past on roller platforms. Gradually these materials were seen to converge from all directions.

There was a noticeable use of corrugated-steel self-supporting stock bins which were moved about by the familiar power-driven lift-truck. Many of the small parts are moved in this manner. As the party crossed the shop at the farther end, frames and springs, upside down at first, were seen to start on their journey down the final-assembly line.



DRILLING AND TAPPING IN INDEXING JIGS — CHROMIUM-PLATING THE PLYMOUTH RADIATOR-SHELL

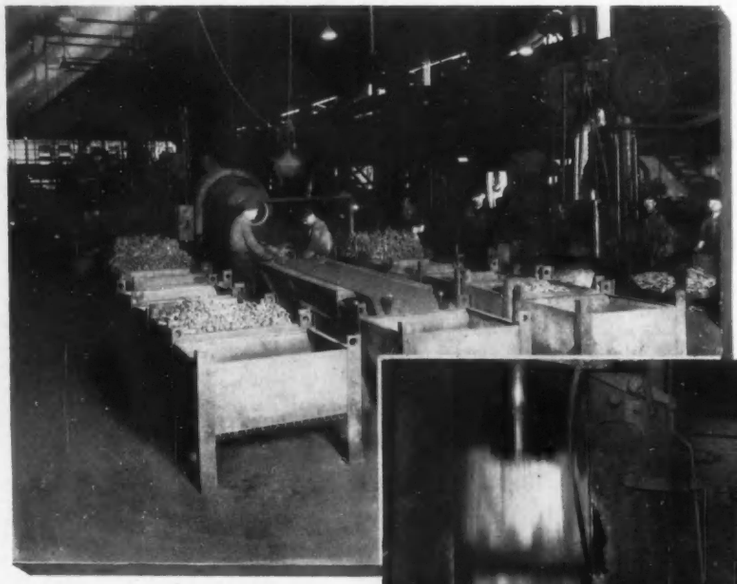
At the beginning of the process line, a network of portable power-driven tools came into view. Power-driven screw-drivers, riveters, hoists, wrenches and the like made assembly rapid and accurate. After the frame and springs had progressed about one-quarter of the distance down the line, a mechanical hoist fitted with a rotating crab-



PLACING THE BODY ON THE PLYMOUTH CHASSIS

like sling grasped the whole and turned it over. Men standing underneath in a concrete trench worked on the lower side of the car, while two other lines of workmen, one on either side, added one after another the several minor assemblies and major units which go to make up the modern motor-car. Finally, when all was in readiness, an overhead crane, controlled by a man in a pendant car, grabbed one of the finished bodies approaching on a line at right angles to the final assembly and whisked it across over the heads of the visitors, lowering it carefully into place on the finished chassis.

Here and there girls in overalls mingled with the workmen, some performing minor assembling tasks, others contributing the finishing operations. Finally, when all was ready and the radiator and tank had been filled, the electric lights were turned on and the switch was thrown, and the finished job was driven off to the floor. The car was then complete except for a few minor tests, in the course of which it entered a stand where its front wheels were held and its rear ones brought into contact with rotating drums. The car was then speeded up, its action was observed, the brakes were tested, and it joined the line on the way to the shipping-room.



INSPECTING VALVE ROCKERS IN CHEVROLET FORGE-SHOP

Chevrolet Plant Uses Many Dies

The visitors to the forge and spring plants of the Chevrolet Motor Co., located in Detroit, also were conducted through the buildings in small groups, each visitor being provided with a pair of goggles. The die-making department was visited first. Here die-sinking machines of various sorts were seen in operation, the most impressive sight being a large battery of Keller machines which automatically form duplicates of dies that are originally made in other machines. Something like a score of these duplicating machines at work, several of them large enough to copy the dies which form the six-throw crankshaft without twisting the bearings, impressed the visitors with the volume of work that is turned out.

Steam-hammers seem to be used almost exclusively in one of the departments where gears, front axles and other comparatively large parts are forged. For parts that require bending or trimming, the necessary presses are arranged with the forges and hammers in convenient groups.

In another building—where many of the parts observed were lighter, such as valve rocker-arms and head-lamp braces—drop-hammers were in use. Little in the way of conveyors was in evidence in these two buildings, many of the parts being placed in heavy steel tote-boxes having their bottoms formed of metal bars or tubes elevated nearly a foot above the floor.

A Mechanized Forging Plant

Mechanical handling is much in evidence in the crankshaft-forging plant, which is designed to be far more nearly automatic in its functions than it might seem possible a forge plant could be made. When the heated square billet is removed from the forge, the tongs are supported by a chain hanging on a freely running trolley which transfers the billet to the steam-hammer with little exertion on the part of the hammer man. Two teams of men are provided to serve the hammers.

Two overhead-chain conveyors carry away the forged crankshaft and the scrap, the shafts going to the heat-treating furnaces in the same building and the scrap being taken away by a conveyor of interesting form, which delivers it to two different points according to its nature. The crankshafts pass through automatic heat-treating furnaces and are inspected and straightened within limits in the same building. Additional photographs and description of this plant and the Plymouth plant will be be printed in the Production Engineering Department in an early issue of the S.A.E. JOURNAL.

THE BILLET THAT BECOMES A CHEVROLET CRANKSHAFT

Springs are made in a separate building which is equipped with mechanical-handling and automatic machinery largely developed by a Cleveland firm which specializes in spring-making machinery. The individual leaves are cut to length, trimmed and drilled before going to the forming-machine, where they are heated, bent to shape in a rotating head or turret and quenched before being released. The leaves are spread with a graphite grease before being assembled, and the assembly line ends at a testing-machine where the pressure required to deflect the spring to a given point is determined for each completed spring.

Operation and Maintenance Featured

National Transportation Meeting Analyzes Instruments, Educational and Army Practices—Banquet and Plant Inspections Enjoyed

MOTOR-VEHICLE transport in all its phases gained further impetus because of the many important questions vital to its growth constructively discussed by eminent authorities at the Transportation Meeting held at Pittsburgh, Pa., Oct. 22 to 24. Numerous new points along lines of intrinsic importance at present were brought out in the papers presented, as well as in the discussion resulting therefrom.

The opening session on Wednesday morning, Oct. 22, threshed out the subject of developing suitable and accurate instruments for recording motor-vehicle performance, occupying the entire time of this session. Maintenance of all kinds of motor-vehicle was given minute consideration in the papers by Messrs. Hewitt, See and Newton in the afternoon, the resulting discussion being especially valuable. As though this were not enough for a day's work, an important joint committee meeting was held in the evening, with resulting decisions made during its session that crowded the early morning hours but will have far-flung effect. A brief summary of this evening meeting will be found on p. 614.

Tractive ability and the method of taking advantage of the latent heat of cooling water were subjects ably presented by A. M. Wolf and Adrian Hughes, Jr., respectively, on Thursday morning, Oct. 23. The afternoon was devoted to the presentation of Prof. J. W. Trimmer's paper on how the principles of economics in motor-vehicle transportation can be taught; and other practical methods having great educational value were analyzed by J. S. Lowe along lines of how motor-vehicle maintenance cost can be reduced by training drivers.

Aluminum alloys suitable for satisfactory construction of motor-vehicle bodies and other parts was the subject of F. D. Goll's paper Friday morning, Oct. 24; and Lieut.-Col. Brainerd Taylor's description of how the United States Army maintains its motor transport concluded the technical sessions.

A specially policed motorcoach trip, sponsored by the Pittsburgh Section and carefully planned by Chairman John Orr and his co-workers, occupied nearly all of Friday afternoon. Its route included all the most interesting sights of Pittsburgh and its environs, and those who elected to go were well rewarded on that score alone. But an additional treat en route was afforded by the inspections made at the Equitable Auto Co. and at the Auto Truck Equipment Co. plants, some details of which are given on p. 614.

Unique Transportation Banquet

The gorgeous Durbar Room of the William Penn Hotel was the scene of the Transportation Banquet on Thursday evening, Oct. 23, the host being the Pittsburgh Section of the Society. Viewed from the entrance to this magnificent banquet hall—whose scheme of decoration was characteristically oriental and created an impression vaguely remindful of pictures in "The Arabian Nights"—one could not fail to be impressed by the basic interest in transportation evidenced by the fact that every dining table was surrounded by its specified quota of members and guests, the total attendance being 310.

Supposedly because of their inherent modesty, the men who were to seat themselves at the speakers' table wore drivers' "goggles" while marching thereto in single file to spirited music rendered by Marty Schram's Orchestra. But after they were seated, the diners put another interpretation upon it and were horrified to note that all these men were goggle eyed! "How terrible!" one might imagine them saying. But suspicion was removed when the goggles were removed, after having caused Laugh No. 1.

Toastmaster Walter Rosenbaum was introduced by J. M. Orr, Chairman of the Pittsburgh Section. Those at the speakers' table are named in the accompanying list, and were individually called upon by the Toastmaster to arise and be introduced to the diners. Applause greeted each introduction.

During the dinner a spritely program of entertainment was followed through. Among the entertainers was a soprano soloist well known in Pittsburgh, in uptodate songs and ballads; two pianists, introduced as the "King and Queen of Ivory," said to be at one time known on the radio as "Twenty Feet of Fingers," who rendered their selections simultaneously on two pianos set end-to-end and in several numbers were accompanied by the orchestra; and a colored entertainer teetotally concerned with grotesque dancing and patter talk. Each number on the program elicited well-deserved and prolonged applause from the entire assemblage.

Team work is the secret of success in many different lines. It was thoroughly coordinated team work that enabled the Pittsburgh Section to stage this snappy banquet program and equip it with all the accessories. We think the Section is to be congratulated on this score alone in addition to the other efforts it made to make the Transportation Meeting a complete success.

TOASTMASTER AND PRINCIPAL SPEAKER AT THE BANQUET

Walter Rosenbaum, Vice-President and Treasurer of the Rosenbaum Co., Who Presided, and F. R. Phillips, Vice-President of The Philadelphia Co., the Principal Speaker

Trends of Today and Tomorrow

F. R. Phillips, senior vice-president of the Philadelphia Co., Pittsburgh, was introduced as the principal speaker following the Banquet, and presented his most interesting paper on Transportation Trends of Today and Tomorrow.

Mr. Phillips showed lantern-slide views of many types of motor-vehicle and of other kinds of transportation, bringing out forcefully the point that efficiency should not be

considered as a fetish but rather as a means of measurement for estimating what efficiency can accomplish. As the slides were shown Mr. Phillips' descriptions, intensified by his magnetic personality, lent added interest that compelled the attention of his audience. Foremost types indicative of future trends included many lines of present endeavor on sea, on land and in the air, which might well be used as a basis for individual imagination and productive results in the near future. This seems a natural consequence of his suggestions.

Performance Instruments

Indicating and Recording Types Analyzed and Standardization Committee To Be Formed

MOTOR-VEHICLE performance indicating and recording instruments were described as to their selection and reliability in a paper by C. W. Stocks, editor of *Bus Transportation*, at the opening session held Wednesday morning, Oct. 22, under the chairmanship of A. H. Gossard. The paper is printed in this issue, beginning on page 529, the author's purpose being to enlist greater interest from the manufacturers in the development of more substantial instruments and to point out how these instruments can be used by all classes of motor-vehicle operators.

Prepared Discussion Presented

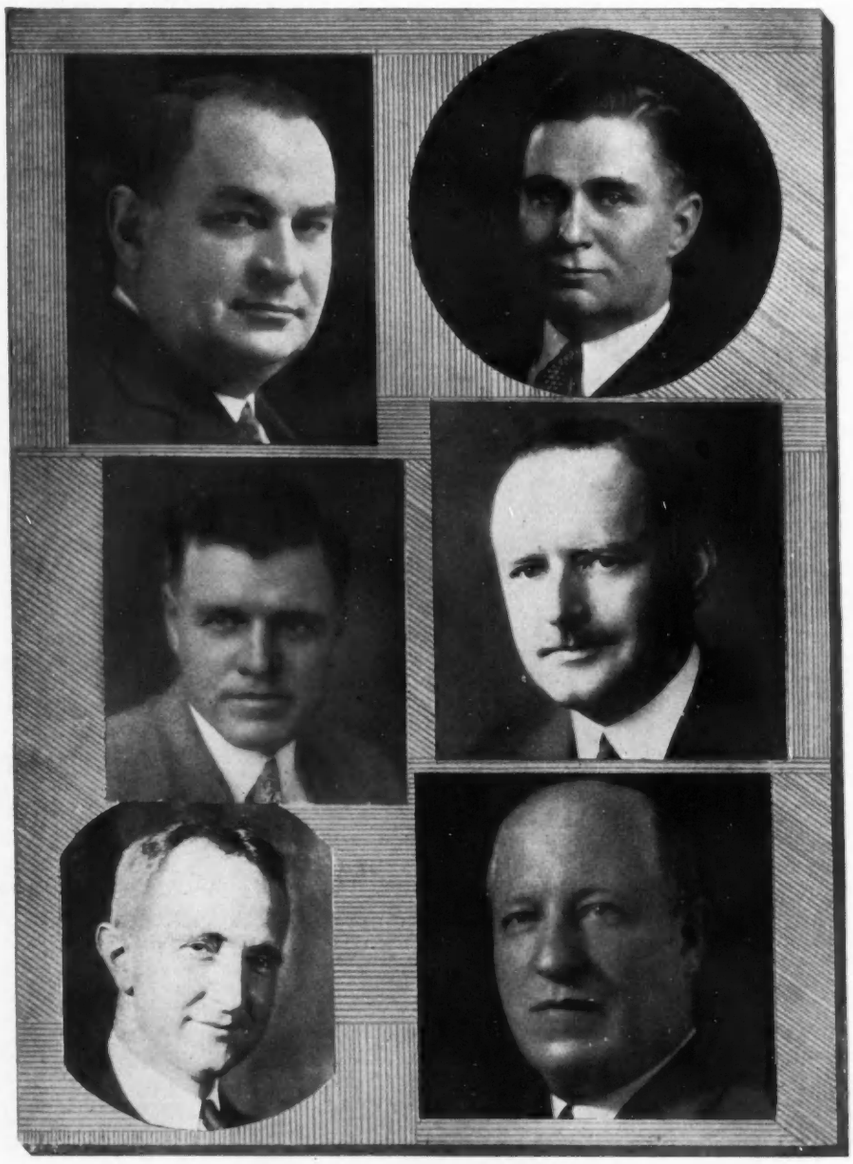
Edward L. Viets' major comment was that the Servis recorder, which he represents, merely tells when the vehicle is running and when it is standing still. Yet he finds that some people do not even comprehend this simple information. But there is a great deal of information that could be gotten from these charts, he remarked, and they could get much more if they really studied them.

All the Ohmer motor-vehicle performance indicating and recording instruments were commented upon by R. T. Abrell, and were illustrated by lantern slides. In conclusion he said that, in the last few years, more attention has been given to developing suitable instruments for indicating and recording vehicular performance, but that more rapid and useful development work with less waste and at less expense can be accomplished only by the operators and manufacturers of vehicles closely cooperating with instrument makers in working out their problems.

H. P. Sparkes, of the Westinghouse Co., remarked that if we used one each of all of the various instruments designed for automotive use on one coach, there would be little or no space left for the engine or the passengers. He discussed tachometers, and brought out points in connection with tachometer developments. He also advocated the design of more compact instrument-boards and exhibited, as a sample, one which evidenced great improvement over former practice.

It was suggested by George S. Andrews, of the R. W. Cramer Co., Inc., that, either through the Society or through some trade organization, the automotive industry collaborate and establish a standard of performance and reliability which the various instruments must meet. He said that, to justify its presence on a modern motorcoach, any such equipment should be able to meet the following minimum requirements of reliability, afterward describing his company's operation-recording devices.

(1) Accuracy; within 2 per cent
(2) Calibration Error; one-half of 1 per cent throughout the scale



CHAIRMEN AND AUTHORS AT THE SESSIONS HELD OCT. 22

(Upper Left) C. W. Stocks, Editor of *Bus Transportation*, Who Presented the Paper on Indicating and Recording Instruments. (Upper Right) H. B. Hewitt, Whose Paper Was on the Scientific Inspection of Motor-Vehicles and Their Units. (Left Center) P. V. C. See, Whose Paper Was Entitled Maintenance To Prevent Road Delays. (Right Center) L. V. Newton, Who Treated the Subject of Motorcoach Maintenance. Below, F. C. Horner (Left) and A. H. Gossard (Right) Who Presided, Respectively, as Chairmen of the Morning and the Afternoon Sessions

Speakers' Table Personnel

J. W. Orr, Chairman, Pittsburgh Section, S.A.E.

Toastmaster Walter Rosenbaum, vice-president and treasurer of the Rosenbaum Co., Pittsburgh

F. R. Phillips, senior vice-president, The Philadelphia Co., Pittsburgh

Horace Wyatt, representing Iliffe & Sons, Ltd., London, England

John A. C. Warner, S.A.E. Secretary and General Manager

C. B. Veal, S.A.E. Assistant General Manager

F. C. Horner, S.A.E. Vice-President, representing Transportation and Maintenance Activities

F. K. Glynn, S.A.E. Councilor

J. F. Winchester, superintendent of motor equipment for the Standard Oil Co. of New Jersey, Newark

A. J. Scaife, consulting field engineer, The White Co., Cleveland

T. W. Noonan, general manager of the Pittsburgh Motorcoach Co.

Adrian Hughes, Jr., superintendent of motorcoach transportation, United Railways & Elec. Co., Baltimore

Hugh M. O'Neill, the Motor Express Co., Cleveland

R. A. Taggart, of the General Motors Truck Co., Pontiac, Mich.

B. H. Eaton, of the Bell Telephone Co. of Pennsylvania

(3) Permanence of Accuracy; no change from the above after a continuous endurance run of 500 hr.

(4) Vibration and Shock-proof 500-hr. Test; to be made on the regular vibration board of the United States Bureau of Standards

(5) Effect of Temperature Change on the Accuracy; none

(6) Ratings for general excellence of design, materials, workmanship and sturdiness.

Speedometers Defended

A. I. Johnson, of the Stewart-Warner Corp., said in part that, concerning speedometers, the difficulty with them in operation is primarily one of failing to specify equipment that is in any way adequate or was designed in any way for motorcoach use. Fully 80 per cent of the speedometer equipment on motorcoaches now in operation is of this type, he asserted. If this light and inadequate passenger-car equipment were replaced entirely with such heavy-duty equipment as has been designed for motorcoach use and as has been available for several years, and if it were scheduled for maintenance the same as other units of motorcoach equipment, the requirements for a motorcoach speed-indicating and mileage-recording instrument would be solved in a most satisfactory manner for most operators. It is the equipment which will give the information most operators desire at the lowest initial cost, that can be maintained with the least expense, and that has been proved by years of use and millions of miles of service to be the most reliable of any such device available.

Joseph Zubaty, of the AC Spark Plug Co., stated in part that, on motorcoaches and commercial vehicles, the problem seems to be different from that on passenger-cars; therefore, a new solution must be found to meet a new condition. He also discussed tachometers.

The General Discussion

F. C. Horner congratulated Mr. Stocks on giving such a comprehensive paper, emphasizing the last paragraph, which was to the effect that accurate records must be kept, no detail is too unimportant to get by unnoticed, and that an exact knowledge at all times within the organization is vital to its success. Mr. Horner pointed out that if these records are not used intelligently, then the records will be of no great value.

John A. C. Warner, General Manager of the Society, remarked that, in connection with the instrument situation on commercial vehicles, the industry may have several things to learn from the aircraft industry. Fliers simply would not fly by instruments, and paid no attention to them. The very definite reason for this was that the instruments were not dependable. Instrument flying came only when the instruments became more reliable. He thinks that, in the commercial-car field, there is to some extent a carry-over from practice in the passenger-car field. But if the instruments are to mean anything they must be maintained, he remarked, because they are only mechanisms and cannot be depended upon to run indefinitely without human assistance. An example of compact arrangement of instruments was cited by Mr. Warner.

A motion was made by Adrian Hughes, Jr., that a committee be appointed to consider the requirements of operating companies for indicating and recording instruments. It was put to vote and carried.

Further discussion of instruments followed, as well as a series of one-minute talks from various members, requested by Chairman Gossard. In closing, the chairman said that, just as motion studies in industry lead to lower cost and greater productivity, movement studies of motor-vehicles will lead to lower cost and more revenue for work performed.

Maintenance Becomes More Scientific

Application of Improved Methods Described in Detail by Three Authors

SCIENTIFIC inspection of motor-vehicles, maintenance to prevent road delays, and motorcoach maintenance-methods, were subjects presented at the afternoon session held Wednesday, Oct. 22. The authors of the three papers were, respectively, H. B. Hewitt, of the Philadelphia Rural Transit Co.; P. V. C. See, of the Northern Ohio Light & Power Co.; and L. V. Newton, of the Byllesby Engineering & Management Corp. F. C. Horner was chairman. About 200 members and guests attended.

Inspection on a Scientific Basis

Visits to the factories and research laboratories of some of the large-scale manufacturers of automotive products resulted in the data which form the basis of the paper by H. B. Hewitt. He said in part that scientific tests and investigations are applied to an extent that is amazing. Millions of dollars are invested in plant and equipment for research, but the cost averages less than 50 cents per vehicle due to quantity production. If definite standards are established by research and engineering, uniformity of quality and performance of the motor-vehicles is accomplished only by effective inspectors.

Although inspection is a critical examination to detect errors, a definite knowledge of particular facts obtained and proved to be correct by scientific research is necessary. When definite knowledge is established, a record which will accumulate and preserve all data under one form should be made so that a standard practice is established. This, applied to motor-vehicle maintenance, brings about a centralization of information by which the maintenance of one type of equipment can be accomplished in a sane manner. Hours of keen observation, mechanical sense, accuracy, thoroughness and practical judgment are qualifications necessary for the highly specialized men selected as inspectors. They thus become properly instructed in standard-practice procedure that can detect faults in a scientific manner.

Mr. Hewitt believes that the economical basis for maintenance can be determined only after studying particular vehicles and their operating conditions. With accurate measuring-devices available for determining the condition of various motor-vehicle parts, it seems that existing conditions and facts should be based on measurement of the time needed to make repairs and the like rather than upon a measurement of elapsed time or of mileage; that is, the men should be diagnosticians rather than to be inspectors who would determine the amount of repairs and the time in which the repairs are to be made.

In conclusion, Mr. Hewitt said that

something seems to be retarding the scientific development of maintenance. He believes that the manufacturers who have concentrated their research facilities almost entirely upon the production of vehicles can divert some part of their facilities to the solution of maintenance problems, thereby reducing the operating cost of commercial vehicles which in many cases would permit the purchase of more vehicles.

As a movement in the right direction, he suggests that the manufacturers of commercial vehicles take the ban off as to the furnishing of blueprints and working drawings to maintenance men, and establish a department to study scientific maintenance in collaboration with the operators so as to establish standard practices for the repair shops. Surely such a policy will be profitable to the manufacturers in providing accurate information for future design, he said, and will also bring about a very close relationship between the manufacturer and operator to the benefit of both.

Maintenance Prevents Road Delays

P. V. C. See based his paper on data obtained from a fleet of 265 motorcoaches mostly of the larger type, and showed how maintenance methods can be applied to prevent road delays. His company has been operating motorcoaches since April, 1922, as well as street cars. Mr. See's data include those for practically every make of motorcoach, although at present only seven different makes of vehicle are operated. City-service motorcoaches

now operating in Akron, Ohio, number 200; and 65 operate on interurban lines extending to other cities.

After describing inspection-garage layout and procedure, the purchase and handling of gasoline, and lubrication procedure, Mr. See outlined the conferences held with the foreman, the clerical system, and the company's practice for heavy overhauls and engine rebuilding. Self-maintenance methods are used. The author described body-repair and painting methods, as well as details of other practices.

In conclusion, Mr. See said that it is very easy for a maintenance executive to deceive himself about his inspection schedules and repair work. He may sit in his office and lay out a wonderful method of inspection, and figure out limits of wear and condemning points for his repairmen, but it is one thing to tell men to do work and another and harder thing to make sure that they do it and do it correctly.

To follow the work properly, he continued, careful checking up must be carried on. Records of road calls, dead motorcoaches, gasoline and oil averages, and costs per motorcoach, all help to supervise the work, especially if the inspection is so segregated that the defect can be traced back to the man or gang that did the work. A personal follow-up by some supervising man is also necessary.

Motorcoach Maintenance

L. V. Newton reviewed motorcoach history and outlined the transition period of development. Operation and maintenance go hand in hand, he said, but too much stress is placed on maintenance methods and not enough on operation. He has yet to find a transportation superintendent who makes motorcoach operation a subject of paramount importance, although the manner in which the coach is driven may decide whether that particular coach makes money or loses it.

In Mr. Newton's opinion the success of any coach and its freedom from repairs is dependent upon how well the driver knows how to drive it and, secondly, upon systematic lubrication and scheduled maintenance. The selection and training of drivers is a function of the transportation department, and too much stress cannot be laid upon it, as well as upon continuous close supervision so that the department is certain that the vehicles are driven correctly.

Mr. Newton advocates that all drivers spend two weeks in the repair shops before assuming their duties as operators, and also that drivers' fitness as operators be passed upon by the maintenance department before the drivers assume their position. He suggests also that when selecting transportation inspectors or supervisors, men having a mechanical background be chosen so that they may be better qualified to note the carelessness and abuse of the vehicles by the driver and to report intelligently on the vehicles' defects when they ride in the motorcoaches.

In conclusion, Mr. Newton remarked that passengers represent the income of the coach business because, without passengers, there can be no income. Profits are measured by the difference between income and the expense of operating coaches. The expense, therefore, is equally as important as the income. Consequently, as much effort should be made toward keeping the expense low as in keeping the income high. Eternal vigilance is the price of low-cost maintenance. No maintenance is good unless it is systematic, because important items are sure to be overlooked. In the organization of the system it is necessary that the buildings, equipment, men and management all be combined to produce one result; namely, keeping the fleet in running order at the minimum cost.

Interesting motion pictures illustrating the operation of the Pittsburgh Motor Coach Co., and the maintenance work being handled by the Equitable Auto Co., followed the presentation of Mr. Newton's paper.

The General Discussion

Introductory remarks made by Chairman F. C. Horner in opening the general discussion included reference to the necessity for the careful selection of drivers. "The driver of your motor-vehicle can either make you or break you," he said.

A. J. Scaife asked whether Mr. See had made an analysis of the difference in cost of reclaiming oil from the entire fleet, versus that of equipping the trucks with filters or devices of that kind. Mr. See replied that he has tried three different types of oil filters

on his coaches, and as yet has not found any that are satisfactory. His oil-reclaiming apparatus has given entire satisfaction.

J. F. Winchester remarked upon all three papers. His major points included the subject of a direct comparison between gas-electric operation and the older type of mechanical operation which many still have and are still operating, saying that these papers do not include anything which gives a direct comparison between the operating cost of the two different types of units; the clogging of the exhaust system, as referred to by Mr. Hewitt; and the necessity for training motorcoach drivers, if the operators are to make profits, stated by Mr. Newton.

H. B. Hewitt answered E. W. Jahn's question by stating that reclaimed oil costs 11 cents per gal., which includes the hauling of the oil to the garage from the central reclaiming plant and back again. In reply to Adrian Hughes Jr.'s question about the use of the watt-hour meter, Mr. Hewitt said that the particular advantage of using this type of meter is that it includes the grades, loads and speeds; in other words, it is really a unit of work, and gives a further analysis for the individual operator.

M. W. Rue discussed Mr. Newton's point in regard to the training of the drivers by putting them in the garage for their first two weeks.

Traction and Cooling Water Studied

A. M. Wolf and Adrian Hughes, Jr., Present Data on Tractive Ability and on Latent Heat

TWO PAPERS were presented under the chairmanship of Dr. W. A. Gruse, of the Mellon Institute of Industrial Research, Pittsburgh, at the morning session on Thursday, Oct. 23. A. M. Wolf's subject was Practical Methods for Determining and Comparing Tractive Ability; and Taking Advantage of Latent Heat of Cooling Water, was treated by Adrian Hughes, Jr.

Comparing Tractive Ability

Mr. Wolf said in part that the underlying principles of tractive ability could have been no mystery to primitive man, who, no doubt, utilized them unknowingly in carrying a load by dragging it on a pole or substituting, for the human powerplant, "motive power" in the form of a beast of burden. Primitive man realized the varying resistance of different terrain, the added exertion when climbing a hill, the increased "advantage" realized by short steps, and variations due to differently shaped pole-ends. It is not to the credit of the present generation that elaborate formulas have taken these principles into account, he continued. The tractive-ability formulas for locomotives antedated the automobile era, and the same essential factors are found therein.

The author stated further that the tractive ability of a motor-vehicle is the measure of its power to overcome outside resistances to its translation, based on the tangential force exerted by the driving wheels at their points of contact with the road. The propelling force is of course derived from the engine. To compute the "tangential force" of the foregoing definition it is engine torque that interests us rather than the horsepower. If the horsepower is given, it can be converted into torque.

After analyzing this point mathematically, Mr. Wolf called attention to the fact that motorcoach design is now in an evolutionary stage and he analyzed typical tractive-factors of modern motor-trucks so that he was enabled to develop an economic factor mathematically, thus being prepared to discuss tractive resistance as opposed to tractive effort. Air resistance was considered in detail as a particularly important factor concerning motorcoaches and Mr. Wolf's points were backed up by diagrams and charts as well as by numerous tables of statistical and computed data. In an appendix other tabular data were presented which show the results made by a testing machine with which the conditions of a tire rolling on a hard smooth surface will be reproduced and rolling resistance measured correctly.

In the ensuing discussion, Adrian Hughes, Jr., analyzed the tractive factor further in the light of his own experience in regard to 55-passenger double-deck motorcoaches. A. J. Scaife discussed efficiencies in high gear and in low gear. M. C. Horine said that his company has always considered efficiency losses in percentage, but that a paper by Professor Lockwood indicated that these efficiency losses should not be figured in percentage but should be figured in horsepower; namely, that a given transmission is given if a greater amount of power or torque is impressed upon that transmission. The loss will not be in proportion to the increase in work done, but more nearly a constant.

Thomas S. Kemble remarked that the paper seems to him to be giving a practical method for estimating comparative tractive ability rather than for determining it. He believes it entirely possible to develop a very simple apparatus which will give the complete answer in a very short test, and thinks also that it would be worth going into.

It was said by B. B. Bachman that, while he subscribes to what Mr. Kemble said, he still believes that there is another phase of the situation which should be considered; that is, unless one is dealing with complete data of horsepower in the form of a curve, it is usually his company's policy to use horsepower at the peak of the curve, which, in most instances, is not the figure that interests the company.

J. W. Shields stated that Mr. Wolf's formula for computing the tractive factor is all very good, but when using that formula it should be kept in mind that there are limits beyond which the tractive factor cannot be taken.

Latent Heat of Cooling Water

Mr. Hughes said in part that a practical method was developed in 1926 and used for increasing the capacity of a cooling fluid for heat dissipation by using the latent heat of vaporization and varying the heat-dissipation capacity of the fluid approximately in direct proportion to the load on the engine. Since then, the system has been used on motorcoaches of the United Railways &

AUTHORS AND DISCUSSERS AT THE THURSDAY MORNING SESSION.

(Upper Left) A. M. Wolf, Author of the Paper on Determining and Comparing Tractive Ability. (Upper Right) Adrian Hughes, Jr., Whose Subject Was Taking Advantage of the Latent Heat of Cooling Water. (Lower Left) B. B. Bachman, Past President of the Society. (Lower Right) J. W. Shields of the Firestone Tire & Rubber Co.

Electric Co. of Baltimore. He expressed surprise that so little interest has been evidenced in this advance in the cooling development on internal-combustion engines, especially as previous papers and discussions have been printed in the S.A.E. JOURNAL and in other technical papers. The new system was developed by Clinton R. Foutz and, in practical operation, it shows results that are beyond anything automotive engineers and operators have heretofore thought possible, said the speaker.

After describing the foregoing system and stating its advantages, also making comments on its various details, diagrams were presented and explained, reference also being made to charts compiled from engineering data obtained from operating tests. Mr. Hughes presented also a diagrammatic comparison between the conventional and the Foutz systems and analyzed their differences. In conclusion, he remarked that the Foutz system is not only applicable to automotive equipment but also to all forms and uses of the internal-combustion engine.

Temperature Effects Considered

Following Mr. Hughes' paper, it was discussed from various angles. Some of the subjects commented upon were the effects of temperature from the viewpoint of the lubrication engineer, whether the higher temperature did not aggravate the conditions where oil fumes as well as gasoline fumes permeate the interior of a motorcoach, and thermostatic control of shutters.

M. C. Horine asked whether or not at the high temperature proposed the combustion-chamber temperature also became so high as to tend toward knocking. Further, he remarked that the limit on compression is how fast the heat can be dissipated to prevent points of incandescence on the combustion-chamber area and that, unless the higher temperature of the water as it passes off is accompanied by a higher rate of heat transference from the combustion-chamber to the water, he failed to see how the necessity for using considerably lower compression ratios at those high temperatures can be avoided.

In reply, Mr. Hughes said that this is exactly the point, in that the rate of flow of water through the jacket compared with the heat to be dissipated is this: The more heat that is given off, the faster the rate is because the vapor would be formed faster and vapor pressure would give an increase in the flow of water; therefore, he continued, one does get more and more heat carried off and more and more heat formed.

T. S. Kemble remarked the statement in the paper that a certain amount of carbon formation existed which was reduced very materially, and suggested that reduction in the carbon formation in this particular case more than offset the increased average temperature of the combustion-chamber wall.

Answering J. W. Cottrell's question whether steam was ever discharged from the system described when the engine has stopped at the end of a long run, Mr. Hughes said that this would occur if, after a long pull up a hill, one suddenly stopped the vehicle. In such cases a small amount of vapor matter would be lost through the pressure valve, but this effect should be compared with the conventional system under the same conditions, in which the cooling liquid boils and a large part of it is lost.

Educational Features

Carnegie Institute Methods and Driver Training to Reduce Maintenance Costs Stated

HOW the principles of motor-vehicle economics are taught at the Carnegie Institute was described by Prof. J. W. Trimmer and how drivers are trained so that they reduce maintenance costs by expert operation was outlined by J. S. Lowe, at the Thursday afternoon session, held Oct. 23. Both papers are printed in this issue, the former beginning on p. 541, and the latter on p. 591. C. F. Kells was chairman, and also is chairman of the Pittsburgh Section's Papers Committee. An audience of 75 members and guests greeted the speakers who held their interest throughout the session.

Should Foreign Languages Be Taught?

In the discussion of the Trimmer paper, S. M. Udale made two criticisms. He noted the absence of Spanish, Portuguese and French in the course Professor Trimmer outlined, and suggested the likelihood that there will be some foreign trade with South America which will give opportunities to men who can speak Spanish and Portuguese. The French trade papers are well worth reading from a trade point of view, he remarked. His general criticism of the course in question, and of all courses in this Country, is that they seem to be directed specifically to take care of inadequately prepared high-school graduates.

Professor Trimmer replied that the Institute accepts a foreign language as an entrance requirement, but does not specify which language. A. H. Gossard suggested that, at some time during the junior or the senior year, there could be a division point where the student could decide into what field of automotive operation he would like to go when he graduates. In reply to Paul P. Pierce's question, Professor Trimmer said that the men visit various plants; they are required to make written reports on what their conception of these plants was. These are gone over carefully and graded by the professors in charge.

Chairman Kells called upon various fleet operators to state their present practice regarding "cadet courses," naming them that; and if they have not conducted those courses particularly for college men, why they have not. Several operators then gave detailed replies. Among them, B. J. Lemon cited his company's experience with students attending the University of Detroit, and said that a number of pairs of these students are working in his company's factory. He referred to students who spend part of their time in industry and part in the college. P. V. C. See also outlined his experience with students from the University of Akron.

MEN INTERESTED IN EDUCATIONAL SUBJECTS

(Left) J. S. Lowe, Who Spoke on Driver-Training for Maintenance-Cost Reduction. (Center) B. J. Lemon, Who Took Part in the Discussion. (Right) Prof. J. W. Trimmer, Whose Paper Dealt with Economic Motor-Transport Instruction

Education's Practical Aspects

Replying to J. A. Harvey's question as to what sort of training Mr. Lowe provides for the operators after they leave the school, the author answered that, since the curve of human memory is decidedly downward, it becomes necessary to review the men on the things that are most essential in the operation of the property. These are periodic reviews. The inspector devotes about 4 hr. per day in the classroom and spends his remaining time in riding the coaches, mingling with and instructing the drivers.

Answering A. F. Coleman, it was stated by Mr. Lowe that his company has six full-time safety supervisors who devote their entire time to riding over the property, checking up on the drivers and instructing them as to any hazardous practices that they must avoid. Periodically, a check-up is made as to whether drivers abuse the mechanical features of the vehicles while driving, and to see that they are taking advantage of the training that they have received.

Accidents and Discipline

Mr. Lowe amplified the statements in his paper with regard to accidents, in response to several questions. This was followed by T. C. Fraser's question as to whether Mr. Lowe would penalize the driver if a motorcoach should be at a standstill while two other cars collided and jammed into the coach. "Would the driver's accident record be spoiled?" he asked. Mr. Lowe replied that if a driver has an accident it deprives him of his privileges, as stated in the paper. The man is not censured in any other way. But there are times when it would be possible for the driver to prevent that particular type of accident if he is alert and anticipates danger, he said, and it might be possible for him to get away from it. Numerous protests against this practice were then voiced by several of the operators in attendance.

After many other questions had been asked and answered as to minute details of training drivers, Pierre Schon said that he was very much impressed with the charts in Mr. Lowe's paper. He noted that his maintenance cost has been reduced from 30 to 26 cents, on a total mileage of over 15,000,000 miles per year. Savings in accidents are there represented as $67,000 per year, at least for the average of the summer months. Mr. Schon thinks this is a remarkable showing, and that Mr. Lowe should be highly complimented on achieving those results. In Mr. Schon's opinion they have been accomplished, primarily, because the drivers had been trained so thoroughly in the school and were thereby made increasingly efficient when called upon to meet emergencies.

New Alloys and Army Methods

Commercial Aluminum Bodies and Military Motor-Transport Maintenance Studied

J. F. WINCHESTER was chairman of the Session held Friday morning, Oct. 24, and presided while two important papers were presented. F. D. Goll's paper on Aluminum Alloys in Commercial Motor-Vehicles was followed by a paper on United States Army Maintenance of Its Motor Transport, of which Lieut.-Col. Brainerd Taylor was the author.

Mr. Goll believes that the trend in commercial transportation equipment is toward the light strong alloys of aluminum, which, developed entirely during the last ten years, are rapidly becoming the accepted structural materials in this line of engineering. Only since the advent of these alloys in commercial shapes have the advantages of reduction in dead weight been fully demonstrated to the truck industry.

Following a statement that commercially pure aluminum is seldom used for structural parts except when alloyed with another element or elements such as copper, manganese, magnesium or silicon, and remarking upon new alloys available, Mr. Goll considered the subjects of design, selection of a correct aluminum alloy for a particular purpose and like matters. He stated the advantages of aluminum bodies as to weight saving, low maintenance-cost, residual value, and better appearance, besides discoursing on the special advantages applicable to certain types of body now in operation. He also presented statistical data in tabular form.

MEN PROMINENT AT THE CONCLUDING SESSION

At the Lower Left is F. D. Goll, Author of the Paper on Aluminum Alloys in Commercial Motor-Vehicles. Chairman J. F. Winchester Is Pictured at the Right. The Top Picture Represents Lieut.-Col. Brainerd Taylor, U. S. A., Office of the Quartermaster General, Who Presented the Subject of Army Maintenance of Motor Transport

A. E. Gresham, of the Standard Steel

(*Continued on p.* 613)

Our Lubrication Notions Upset

Baltimore Section Speakers Assert that Crankcase Oil Should Not Be Changed—Oxidation and Carbon Beneficial

THE 100 members and guests who attended the Sept. 24 dinner-meeting of the Baltimore Section became so immersed in lubricating oil that they did not emerge until 12:30 a. m., constituting a 6-hr. session, if the time occupied in consuming the dinner is added to that spent in taking the dose of oil.

Almost everything that has been taught for years concerning the use of engine-lubricating oil was controverted in the course of the session, which was presided over by Section Chairman G. O. Pooley, superintendent of buildings and supplies for the Chesapeake & Potomac Telephone Co., who expressed gratification because of the excellent attendance at the initial meeting of the new season.

Old notions about lubrication had plenty of supporters, who questioned some of the speakers in obvious efforts to find flaws in their test methods and seemed unwilling to accept the findings announced. The first advocate of changing crankcase oil periodically with mileage was A. F. Masury, vice-president and chief engineer of the International Motor Co., who gave a humorous and interesting address on Engine Lubrication, illustrated with slides showing the lubrication system of Mack truck and motorcoach engines. He paid a tribute to the late Mr. Saybolt for the research work done and instruments devised for testing oils, but said that, after making all the engineering and scientific tests, we have to come back to our practical experience of which oils and lubricating systems work best. From this experience, he said he thinks it is safe to say that crankcase oil should be changed, and the oftener the better.

Air and Oil Cleaners on Trucks

On the table before him, Mr. Masury showed an air-cleaner, an oil-filter, an oil pump having a strainer at the bottom, a pressure gage, an oil-bypass regulator, two types of connecting-rod with different oil grooves, and a crankcase in which the oil pipe is cast in the aluminum case to prevent it being shaken loose by vibration. Since motor-trucks work today on concrete roads, in road-construction work, at cement works and rock-crushing plants, and in desert sand, the speaker's company now uses an oil-filter on its trucks through which the oil can be passed to remove the abrasive material and other foreign substances. Although several different types of oil-cleaners are in use, the amount of good they do depends on how often they are cleaned by the truck operator.

With the higher engine-speeds and longer working hours common today, complaints are received regarding rapid engine-wear, and the manufacturers are accused, said Mr. Masury, of not using as good materials as formerly, although metallurgical examinations show that the cylinder steel and piston materials are better than ever. However, the trouble can almost always be traced to the lubricant or fuel used or to improper care of air-cleaners and oil-filters. The experience of his company has been that the most economical method of engine operation is to keep the temperature of the engine up, do as much as possible toward correct maintenance of the various filters, and provide the engine with fresh oil bought under specifications from reliable oil companies. Changing the oil at regular intervals of 1000 actual miles of operation is a good rule that would assure safe operation in a majority of cases.

Frequent Oil-Changes the Safer Policy

In support of his belief, the speaker cited a case in which this program had been followed and, after three years of operation in which the vehicle had covered 80,700 miles, the engine was taken down for the first time and given a general overhaul. The cylinder showed a maximum wear of 0.010 in., the pistons 0.001 in., the bearings 0.005 in. and the piston-pins were tight. The most noticeably worn moving parts were the oil-pump gears.

Although the company fits one of the best air-cleaners on its engines, Mr. Masury said that not 10 per cent of the Mack trucks have it on, as the first thing a driver thinks is that it chokes up, and he takes it off. Everything possible has been done to train the company's service-station man, to educate the users, and in the way of mechanical ingenuity, to make it possible to use oil longer in the engine, but Mr. Masury still believes it is safer to change the oil frequently. He paid his compliments to the chemists, whom he called "the greatest fakers in the world," by saying that "they can make any oil have any viscosity they want it to have and can make any bum oil from any part of the world equal Pennsylvania oil." So he believes that the only safe thing to do is to buy oil from a reliable company and believe in its integrity. However, he conceded that "nothing is so marvelous as the new hydrogenation process and its possibilities" and that refineries today are making marvelous lubricants out of Texas oils that 20 years ago were regarded as almost unfit for lubrication.

Mr. Masury was cross-questioned at length on many points by A. P. Petre, of the American Hammered Piston Ring Co.; V. P. Williams, of the Automotive Corp. of America; Joseph Bavette, of the Yellow Cab Co.; and P. E. Pendleton, of the Berliner-Joyce Aircraft Corp.

Used Oil Good When Abrasive Particles Are Settled Out

The second speaker, C. S. Bruce, of the Bureau of Standards, remarked that there is a chance of being too careful or of not being careful enough. He does not believe in wasting oil, which costs money. "If you buy from a reputable manufacturer, you will get a good oil," he said. "You can add gasoline to it, babbitt material and a little iron, most of the particles of which will settle to the bottom of the crankcase, and the only way you can get them out is to pull it down and scrape it with a putty knife. Draining the oil will not remove them, but it will remove oil that has from 10 to 25 per cent of gasoline heavy ends that do not burn. If you put in new oil, the engine has to add whatever will make a balance. If you run it too hard, the amount of gasoline will decrease to 10 per cent, and, if you operate under cooler conditions, it might come up to 30 per cent."

If the viscosity goes down, continued Mr. Bruce, the bearing surfaces come closer together and certain abrasive particles will cause wear, but if the viscosity is increased particles of that particular size will not touch the surfaces. He said that he believes an oil does not change its characteristics in operation in an engine except that it probably oxidizes and becomes browner. He suggested that if a fleet operator would drain the oil out of his engines and let it stand for about three weeks to settle, then pour the top off, he would have a perfectly good lubricating oil, as gasoline has already been added to it.

Tests Show Oil Changing Unnecessary

Chairman Pooley next called upon A. C. Aston, of the Chesapeake & Potomac Telegraph Co., which operates more than 200 Ford Model-A cars and trucks and about 50 Model 51-A White trucks, to recount the experience of the company with the no-oil-change investigation it started about two years ago.

Mr. Aston first briefly reviewed the published reports of research on oil deterioration in engine crankcases, which he said reveal a wide diversity of opinion and even contradictory conclusions, but the more recent investigations confirmed the opinion that frequent oil changes are of doubtful value. Data from tests on vehicles of the telephone company's fleet, several of which have been run in excess of 30,000 miles with no oil change, were presented in support of the contention that frequent oil changes are not necessary.

Some of Mr. Aston's statements were as follows:

Tests have shown that in some cases the oil, after use, has a higher viscosity than the new oil.

A desirable oil for use during cold weather is one that gives quick circulation at low temperatures and which also gives ease in cranking.

The normal dilution of used oil during cold weather produces the required satisfactory oil condition.

Aside from the direct saving from this practice, due to a smaller consumption of oil, we feel that certain other savings are effected that amount to many times the value of the oil. These savings arise from the characteristics of used oil which provide more effective and satisfactory lubricating film in cold weather, particularly during the warming-up period, a more rapid circulation of the oil to the bearing surfaces, and require much less torque to start the engine, thus resulting in less current drainage from the battery and less strain on the starting motor.

The general trend of these figures seems to be that the flash and fire points and the viscosity become stabilized after a few thousand miles of service.

A sample that had gone 50 miles was apparently as black as a sample that had gone 200, 300 or 500 miles.

The various levels of sediment were found to be in proportion to the odometer reading of each vehicle.

A sample of the sediment, after the oil was washed from it and it was allowed to dry, was found to contain 66.7 per cent carbon, 32 per cent iron oxide, a trace of silica and a trace of calcium oxide. From this it seems evident that what road dust enters through the carbureter passes out of the engine in the exhaust.

Coarse material in the crankcase will always remain there, whether the oil is changed or not.

The black material that circulates through the engine is not harmful, because it is nothing more than smoke which finds its way past the pistons.

We investigated the condition of an engine taken from a vehicle that had run 39,101 miles and compared it with the specification requirements for a new engine and found the following:

Cylinder wear—Piston-ring travel, 0.013 in.; piston-skirt travel, 0.0005 in.

Crankshaft and connecting-rod bearings wear, 0.001 in.

Crankshaft end play, 0.002 in.

Connecting-rod end play, 0.001 in.

Answering a question by F. K. Phillips, of the United Oil Co., Chairman Pooley stated that the telephone company has a record on some cars in which oil changes have been made religiously every 500 miles and that have delivered about 170 miles per quart of oil, and on cars in which no change was made that have delivered 213 miles per quart.

Many other questions were asked in the discussion, which was participated in by Mr. Phillips, Mr. Masury, Mr. Bavette, A. B. Gardner, of the United Oil Co.; V. C. Young, of Mack Trucks; and W. K. Marshall, of the Rice Bakery.

Erratic Performance of Blended Oils

W. A. Beck, automotive and industrial engineer of Sherwood Brothers, next recounted some tests made last summer on motorcoaches operated by the United Railways & Electric Co. of Baltimore to determine the characteristics of paraffin-base, naphthenic-base and blended oils as to their action in engines. Viscosity of the paraffin-base oil fell in the beginning and became stabilized at about 1000 miles of operation on the road. The gasoline consumption reached the maximum in the vicinity of 500 miles, and the miles per pint of lubricant make-up fell off very rapidly and reached a low point at 400 miles, then flattened out. Dilution started at 7 per cent and fell off to 6½ per cent. Between 1000 and 2500 miles, the viscosity rose gradually on several motorcoaches, the dilution dropped somewhat and stabilized, and the miles per gallon dropped abruptly at about 1800 miles, then rose again. From then on the miles per gallon, the viscosity and the percentage of dirt remained almost constant to 6500 miles of operation.

Much the same conditions were observed with respect to the naphthenic-base oil, except that dilution was approximately 10 per cent at the high point and the dirt went as high as 12 per cent.

With blended oil the viscosity dropped abruptly at first, then rose in a curve to approximately 1000 miles. The dirt rose abruptly to 1800 miles, then dropped and increased again, varying between 0.1 and 5.0 per cent. The low-priced blended oils did not stabilize as soon as the straight refined oils did, and Mr. Beck feels that a certain amount of distillation and rectification goes on in the engine. When the characteristics of the oil are not stabilized, the contamination by dirt and water, he said, goes high.

No attempt was made to correlate fuel consumption with the different oils tested, but somewhat better mileage was obtained with the paraffin-base oil, which gave the smoother curves. The tests did not result in any definite determination as to what oil the company would continue to use, except that Mr. Beck said that he did not think he would want to use the blended type. Regarding changing the oil in the crankcase, he said that, if the dirt did not show an increase again at 10,000 to 15,000 miles, he would advise using the oil until the increase became manifest and then would investigate to see if it needed changing.

Two engines that were measured with a micrometer showed wear of 0.002 in. in the cylinders after 3500 miles.

An interesting point was that, with accumulation of carbon in the combustion-chamber, the compression increased from 65 to 85 lb. per sq. in., and in one case to 92 lb., showing that the carbon has some sealing effect, according to Mr. Beck.

Engine Operates Worst on New Oil

The last speaker on this subject was Dr. Penniman, who had been associated with Mr. Beck in the work described by the latter. The comparison of paraffin and naphthene-base oils in the tests was not entirely fair, he said, as the majority of oils that must be used must come from blended material, but he believes that the oils can

be blended to smooth out the curves, which are irregular in the first 1500 miles of operation.

The most important fact is that the first several hundred miles after putting in new oil, when the engine is supposed to be at its best, is the very worst time for operation of the vehicle, both in starting and running and in gasoline consumption. This means, said Dr. Penniman, that the oil is entirely too high in viscosity. Our first interest is in the clean properties of the oil, and then to get as low viscosity as we can. In airplane operation during the World War, used oil was found to be superior to new oil. He believes that oxidation, which we have been trying to avoid, is the very thing we should seek, the formation of acids, but not sulphuric acid, being really desirable. The United Railways Company has been running motorcoaches with great satisfaction on oils of low viscosity to which a certain acid has been added.

Passing back Mr. Masury's compliment, the speaker remarked that, in spite of being fakers, the chemists are "on the way to solving the lubrication question with the cooperation of those fakers we call engineers and those still greater fakers we call oil men."

Replying to questions, he said that the motorcoaches did not have oil-filters or rectifiers and he thinks that any rectifying can be done better in the shop than on the engine. However, he believes in air-cleaners, as heavy grit settles in the crankcase and the case has to be taken down after 25,000 or 30,000 miles and cleaned. Oxidation, however, aids lubrication rather than the reverse, as it tends to increase compression. He said that he is a great believer in using old oil; new oil oxidizes much easier when seeded with old oil. He is convinced that a certain amount of carbon or semi-oxidized product in oil actually aids its lubricating quality.

Advantages of Petroleum Hydrogenation

The evening's long program was concluded with a paper on Hydrogenation, presented by Marion Boyer, director of research of the Standard Oil Co. of Louisiana. He explained this, in general, as the process of combining hydrogen chemically with elements or compounds, and, as applied to the petroleum industry, as adding hydrogen to crude petroleum or its products at high pressure and temperature in the presence of a catalyst to produce high-grade gasolines, kerosenes and lubricating oils. Lantern slides were displayed to show the first commercial petroleum hydrogenation plant in the world, which started operating on Aug. 7, this year, at Bayway, N. J.

Comparing cracking, which yields about 60 per cent gasoline and 40 per cent low-quality residue, Mr. Boyer said that hydrogenation builds up instead of breaking down the chemical structure and yields from 102 to 104 per cent of high-quality products from a low-grade charging stock. It is a long step forward from cracking and enables extremely close control to be exercised over the chemical composition of the resulting product. In addition to the extremely high yield, the process results in the virtual elimination of sulphur compounds. Runs of low-gravity Mid-Continent and Venezuela stocks gave motor oils having flash and fire points and viscosity indexes considerably better than those of oils made from the most select Pennsylvania crudes. They also showed lower carbon and wax contents, said the speaker.

Hydrogenation now makes the refiner independent of the grades of crude oil, and even of crude oil altogether, as coal, lignite or almost any carbonaceous material can be used, and the process can be flexibly operated to produce high-quality refined products in proportion to the demand, thereby assuring the manufacturer and the user of automotive vehicles of an unlimited supply of superior fuels and lubricants.

Two Papers on Steel

Cleveland Industry and Stainless Steels the Subjects at Local Section Meeting

STAINLESS steels, their production, forming and value to the user of motor-vehicles were thoroughly discussed at the Oct. 15 meeting of the Cleveland section. Prior to the main paper of the evening, delivered by M. J. R. Morris, metallurgist of the Republic Steel Corp., E. L. Shaner, editor of *Steel*, presented an enlightening summary showing the place of Cleveland in the steel industry.

Nearly 100 members attended the meeting. Four teams of 22 members participated in the old English game of carpet bowls, put on as the first of a series of pre-meeting attractions designed to fill in the time between close of offices and the meeting dinner. P. V. C. See, of Akron, Ohio, was introduced as the new Vice-Chairman, to succeed W. E. England. The latter resigned recently, on account of taking up work outside the Section territory.

Changes in Cleveland Steel Industry

Changes in character of demand, in points of important consumption and in location and ownership of the steel plants, all have had an important influence on the Cleveland steel industry, according to Mr. Shaner. The automobile manufacturers require highly finished sheets and strips—products which were almost unknown in 1900—as well as many varieties of carbon and alloy steels. Marked increases of consumption in southern Michigan, in northern Illinois and in Wisconsin have attracted many producers to the cheap land in northern Indiana and to the low-lying area between Toledo and Detroit, Mr. Shaner pointed out.

Virtually all the Cleveland blast furnaces, steel works and rolling mills, which a few years ago were operating independently, are now affiliated with producers or mills in other districts. Steelmakers of Cleveland and northern Ohio have their best opportunity in special, highly finished products that are adaptable to profitable markets. Among these products Mr. Shaner mentioned the chromium-nickel steels, now made by 46 companies to the extent of 25,000 tons a year. The new era, in which steel is offered as a special product to do special work and not just a tonnage product, should be welcomed by the automotive industry. In the past the industry has had to fight for the greater variety of analyses and physical properties it desired, Mr. Shaner declared.

Stainless Steels and Their Uses

Mr. Morris's paper was well illustrated with slides showing stainless-steel production processes and unusual applications in the automotive and other industries. Among these were views of tubes for petroleum-cracking stills, designed to withstand a temperature of 1800 deg. fahr. at 1000 lb. pressure; and locomotive firebox sheets with self-cleaning characteristics, due to the difference in coefficient of expansion of the sheets and the scale accumulated in service. His display of stainless steel parts, wire wheels, windshield frames, radiator shells and hub caps, produced for various manufacturers, was examined with interest until a late hour. The paper and display covered mainly automotive applications, in sheet or flat form rather than in bulk-metal parts such as forgings. Stainless steel is being used by the industry, one speaker explained, for light articles in which the cost of material is small.

The increasing applications of stainless steels are responsible for improved appearance and more durable finish of many important automobile parts, according to Mr. Morris. He traced the

history of the group of ferrous alloys, popularly called stainless steels, from their first use in gun barrels and for household cutlery to their present use for radiator shells, windshield frames, and hub, gas-tank and radiator caps and similar articles.

Resistance to atmospheric corrosion, and a beautiful and fashionable finish are outstanding characteristics of the new stainless steels, said Mr. Morris. This resistance is being secured by first pickling the metal parts and then grinding and buffing the surface to make sure the scale is entirely removed.

For conditions where the surface must be protected against liquid or wet corrosion, as in parts that come within splashing distance of the ground, the chemical composition of the metal must be such that the carbon is held in solution or is not precipitated locally. A greater percentage of chromium is helpful, Mr. Morris explained, as is also the addition of nickel and silicon to the fundamental alloy of chromium and iron. The speaker also referred briefly to the high-chromium alloys used for parts such as engine valves, which must resist dry corrosion.

Points Covered in Discussion

Prominent in the discussion following Mr. Morris's paper were: O. A. Parker, of the Parker Wheel Co., who presided; R. R. Abbott, of the White Motor Co.; J. S. Adelson and L. W. Adams, Jr., of Steel & Tubes, Inc.; Paul Gygi, of the Champion Machine & Forging Co.; S. A. Harris, of the Steel Improvement & Forge Co.; and C. G. Shontz, of the Eaton Axle & Spring Co.

Mr. Parker called attention to the fact that rolls and dies must be stronger for stainless than for ordinary steels, and that the cost is about 12 times as great. Mr. Gygi described tests on stainless-steel forgings, which showed an elastic limit of 64,000 lb., ultimate, 105,000; elongation, 49 per cent; and reduction of area of 63.2 per cent.

Mr. Shontz raised the question whether stainless could be used in contact with ordinary steel. The coefficient of expansion of 18 chromium is less, he said, and of the 18-8 chromium-nickel stainless steels is more than that of ordinary steel. He asked whether it would be possible with an intermediate composition to get the same coefficient. This is being accomplished in the oil industry, Mr. Harris indicated, by a composition of 8 per cent chromium, 20 per cent nickel, 1 per cent silicon and 0.35 to 0.40 per cent carbon.

Inspectors accustomed to judging plated products are likely to be too strict with stainless steel, according to Mr. Shontz. Small pits are not objectionable, he thinks, when they can hardly be detected without a magnifying glass. Even though the stainless does not have as good an appearance at first as the plated surface, he believes that after a year's service, in most cases, it will be better.

Mr. Abbott referred to the practice of copper-plating steel to provide a good paint surface, and implied that some such method might be used to lower the cost of stainless steel. Mr. Adams mentioned the importance of heat-treatment, in addition to carbon in solution, in securing surface stability of the stainless steels. Responding to his query about welding, Mr. Morris said that the 18-8 type was the most easily welded. Acetylene or gas welding requires a flame that is neutral or slightly reducing.

Service-Manager Problems

Oregon Section Told How to Treat Customer and Diagnose Engine Trouble

INTEREST in problems of the service manager held the attention of 76 members and guests at the Oregon Section meeting held at the Multnomah Hotel in Portland, Friday, Oct. 10. Two papers, one by Don F. Gilmore, service manager of the Sands Motor Co., of Seattle, on The Service Manager and the Customer, the other by W. A. Gill, of the Gill Automotive Service, of Portland, on Automotive Maintenance Problems, were ably presented by the authors and interestingly discussed by the members.

The attitude of the customer is different when purchasing service from that which it is while making any other purchase, according to Mr. Gilmore. In most cases servicing is an expense that the customer did not consider very seriously when purchasing the car; many times he finds it necessary to make extensive repairs he did not plan on at all no matter how long he has driven the car. Moreover, he is suspicious of repair shops in general. He is sure the shop is just waiting for an opportunity to charge him a big price for a little work. Therefore, as service men, we are faced with the problem of selling a man who is suspicious, something he does not want to buy, at a price he does not want to pay.

Experience has taught that there are five major steps in selling service: greet the customer with a smile and hold your poise, show an interest in what he has to say and sympathy for his troubles, create confidence in him as to your ability and integrity, sell your service for a price that will enable you to show a profit and have the price understood, and, last but by no means least, show him that your interest is more than just to get his money by the courteous delivery of the car and a follow-up system to be sure that he has been satisfied.

Gain Customer's Good-Will

Let the customer's first impression be one of friendly reception. If he comes in with a grievance, real or imaginary, hold your poise. Never lose your temper. When angry you are not master of yourself, let alone master of the situation. Make the tempo of your speech suit the customer. If he is in a hurry, make your answers short and to the point; if he is in a talkative mood, spend more time with him.

Show your interest in him and the troubles he is having with the car. Give him your undivided attention until he has finished with all he wants to say. Do not interrupt him with a solution of his problems one at a time. Waiting will give you more time to formulate your answer and he will be in a better mood to listen to you after he is through talking.

Create in the owner's mind confidence in your ability. To do that you must know your subject thoroughly. Be exact in your answers and explanations. Take time enough to explain to him just what must be done to get the results he is after. Show him, if possible by means of cutaway models, just how each part functions, how it may get out of order, and what different steps are required to fix it. Be sure that what you are going to do to the car will accomplish the result he has in mind.

After you have accurately determined what has to be done, quote your price on each operation. See to it that the owner understands the price and agrees to it. That point will save argument over the bill and much trouble in collecting.

Be sure that no grease spots are left on the car when the work is completed. When your customer has come after the car and paid the bill, do not just show him the car, leaving him to get it out himself as though you were through when you had his money. Go with him to the car, help him get it out, see to it that the transaction is closed with the same solicitude it was received. Keep a record of the job and use some kind of a follow-up afterward to make sure you have added a booster.

Diagnosing Engine Troubles

That carelessness on the part of the service manager in obtaining the car

owner's point of view, and too much guess work in diagnosing engine trouble is responsible for many unnecessary repair operations and much owner dissatisfaction, is the conclusion of Mr. Gill after many years' experience in automotive repair work. The remedy lies in a better knowledge of engine functioning, a more careful analysis of effects of the non-functioning of each component unit, and more exact methods for determining the degree of operating perfection.

The major functions involved in engine performance are compression, timing of valves and ignition, ignition, carburetion, lubrication, and cooling. Enumerating under the head of each function the troubles that contribute to lowered efficiency, Mr. Gill pointed out the effect on the operation of the engine and the symptoms to look for. Troubles of particular importance often overlooked, such as improper valve-spring tension, condenser breakdown, spark-plug gap, breaker-point gap, breaker-cam synchronization, spark-coil breakdown and scientific carbureter adjustment, were particularly stressed by the speaker.

A desire for more accurate equipment for testing engine performance led Mr. Gill to develop a complete testing unit for use in his engine clinic. This test unit embraces a pressure gage for testing compression, a vacuum gage for testing intake-manifold suction, Orsat apparatus for exhaust-gas analysis, a milliampmeter for condenser testing, a neon tube for testing spark miss, an eight-point distributor connected to eight graduated spark-gaps and driven by a variable-speed motor for testing coil performance, test lamps and pilot lamps for testing electrical circuits, a variable spark-gap combined with a graduated dial, a spark gap in a variable-pressure chamber, and other necessary instruments such as switches, voltmeters and ampmeters.

When a car is brought in for work on the engine a thorough test is made and its condition recorded on a special form developed for the purpose. The necessary repair operations are determined from the condition of the engine as revealed by a study of this record. Use of the apparatus and the method has removed guesswork from the diagnosing of engine troubles and resulted in better customer satisfaction.

Both of the papers prompted lively discussions, participated in by many of the members present.

A Modern-Metals Meeting

Non-Corrosive Steels and the Nitriding Process Explained to the Indiana Section

THE Modern Metals meeting of the Indiana Section, held Thursday evening, Oct. 9, was opened by a paper by C. C. Snyder, metallurgist of the Republic Steel Corp., of Massillon, Ohio, who presented a survey of stainless and other non-corrosive steels. J. Muller, chief engineer of Leeds & Northrup, Inc., of Philadelphia, gave the second paper, on Nitriding in Industry. Following the papers, a very lively technical discussion started, in which many engineers and production men asked for facts that were not presented in the two papers.

"There is no cure-all for metal corrosion," holds Mr. Snyder, who said and very clearly showed in his paper that "no one alloy is a cure-all for all occasions. Each analysis has its own limits and, if these are faithfully adhered to, justifiable results will be the reward. Much of the misunderstanding and confusion among steel users, and I might say among the makers as well, has been the result of a lack of information and not because of any intention. We believe that most of the propaganda now being dispensed is reliable and will do much to clarify the stainless picture as a whole."

Mr. Snyder divided corrosion into three classes: atmospheric corrosion, resulting from exposure to weather conditions; wet corrosion, caused by partial or complete immersion in corrosive liquids; and dry corrosion, which is scaling at elevated temperatures. In the atmospheric-corrosion field, the greater the content of chromium is the more complete is the resistance to weathering, staining and rusting. In the wet-corrosive field, so many factors enter that it is difficult to recommend a certain type of alloy unless all the details are accurately known; "for that reason we usually ask the prospective customer to make a service test in the field." In the dry-corrosive field, chromium and chromium-nickel alloys are largely used, the type of alloy being determined by the operating temperature of the furnace; the higher the temperature is the greater the chromium and nickel content should be. But, to properly prescribe, the metallurgical doctor must also know whether the heating is to be continuous or alternating hot and cold. Some of the alloy types have the tendency to cast off their protective scale when alternately heated and cooled, and therefore rapidly fail. Mr. Snyder then gave a detailed description of the most widely used alloys and showed why their uses are justified.

Hardening without Complexity

Mr. Muller's paper was a comprehensive and detailed account of the nitriding process. The speaker traced the struggle through difficulties, explained how they were overcome, and stated that nitriding is now producing extremely hard surfaces on finished parts made of suitable steel and is obtaining all the advantages inherent to high hardness without subjecting the finished part to complex heat-treating. He added, however, that "the life of nitrided parts under various service conditions is still unknown. Laboratory tests for corrosion, for wear, and the like, do not always accurately predict the true service life of nitrided parts." After a complete analysis of the process, Mr. Muller devoted considerable time to describing apparatus.

Following the presentation of the papers and the slides offered by each author, the meeting went into high with questions shot at both speakers by hardy engineers and production men, who had encountered trouble of one sort or another in attempting to employ some of the newer metals before the good propaganda to which Mr. Snyder referred had become properly disseminated apparently. None of the questions were "smart attempts to get something on the speaker," but indicated downright desire to learn things of a practical nature from two men who made it very evident that they knew their topics and also at least some of the limitations of these newer alloys that in some fields have not yet written their curves of actual wear and tear.

The meeting was pronounced a very practical one by those in attendance. The subject did not draw a season-record crowd, because of its highly technical nature, but more than 100 followed the papers and the discussion with great interest.

Chairman Schwitzer announced that the next meeting, to be held Nov. 12, will be on Modern Traffic Control, both for city streets and country highways.

Lower Airplane Costs Predicted at Syracuse

NEW USES for aluminum alloys, principally as they influence the development in aircraft engineering, was the subject of the meeting of the Syracuse Section at the Hotel Syracuse, Oct. 7. G. D. Welty, research engineer of the Aluminum Co. of America, was the principal speaker. His paper on the various uses of aluminum alloys contained a mass of technical information covering developments in this field of research from the time the Wright brothers made their memorable flight at

Kitty Hawk, N. C., in 1903, through the World War to the present.

Mr. Welty stressed the importance to the future of aviation of bringing production costs to a new low level that will meet the strict competition of land transportation. Until this is done, the airplane, according to Mr. Welty, will be confined largely to two fields: Government services and private aviation for pleasure.

A substantial drop in manufacturing costs within the next few years is anticipated by the speaker, because of simplified methods in the development of alloys, making for light engines. From this he foresees a construction of airplanes that will make them an economical means of transportation, both from the commercial and the individual pleasure-car viewpoints.

E. S. Marks, chief engineer of the H. H. Franklin Mfg. Co., presided. L. C. Mattice, representative of the Alliance Motor Corp., gave a short talk on the new Austin car, and A. J. Underwood, director of aeronautic activities of the Society, brought the good wishes of the National body to the new Section organized in Syracuse last spring.

Servicing and Development

Northern California Section Listens to Two Papers on These Phases of Aviation

APPROXIMATELY 80 members and guests attended the Aeronautic Meeting of the Northern California Section which was held on Oct. 9 at the Curtiss-Wright Flying Service field, Beresford, Calif. Following the dinner two papers were presented. The first was by Herbert Marsh of the Boeing Air Transport, Inc., and dealt with airplane and engine servicing. The other by Edwin Cooper, general manager of the Oakland Branch of the Pacific Airmotive, outlined the development of the aircraft engine in the last 20 years.

While the airplane is really an automotive vehicle of slightly different form, and servicing it is similar to the servicing of automobiles, said Mr. Marsh, a difference between the two does exist in that the engine is seldom manufactured by the airplane builder and the powerplant installation usually is neither designed nor installed by the engine manufacturer. As powerplant installation has a decided effect on the reliability and operating cost of the engine and the airplane, whether the airplane or the engine manufacturer should be held responsible for the installation is a question. In this connection he cited the case of a number of airplanes recently sent across to the west coast during the summer when the landing fields were all more or less dry and dusty. On these airplanes the carbureter intake extended through the bottom engine cowl, pointing toward the ground and slightly toward the propeller. When an engine was being warmed up a vertical column of dust, which was formed by the propeller, became distorted by the propeller blast and the suction of the carbureter intake as it rose from the ground. This resulted in large quantities of dust passing through the air intake and eventually into the cylinders, a subsequent checking of the cylinder carrying the master rod showing that the wear caused was equivalent to several hundred hours of flying time after the engine was altered to take a downdraft from over the top engine cowl.

Systematized Inspection and Servicing

The steps taken by a growing organization to systematize the inspection and servicing of airplanes was briefly described, the report form being divided into groups, each covering an assembly or unit such as the cylinder assembly, carbureter, magnetos or control surfaces. These groups are in turn subdivided to show which part must be inspected, adjusted or greased with a space for the initials of the mechanic performing the operation. With this system no duplication of work occurs, neither is the checking of certain parts likely to be overlooked. If the servicing should be incomplete when a change of ground crews is made, matters are simplified for the oncoming crew since the inspection report will show all work that has been done.

Climatic conditions regulate servicing and the usual practice, wherever possible, is to carry both gasoline and oil in bulk. Oil should be stored in heated containers during the winter season and if a flight is scheduled to start early in the morning, the engine should be kept warm overnight by a canvas hood that is arranged to take a pipe 12 in. in diameter leading directly from a hot-air furnace to the bottom of the engine hood. With this arrangement an engine can be warmed in a very short time.

In conclusion the speaker stated that the aviation engine could now be considered as thoroughly reliable as mechanical troubles seldom cause forced landings. Engines when now removed for an overhaul are found to run as smoothly as when first installed and sometimes more so. Changing engines approximately every 250 hr. eliminates the work of top overhaul and enables a production schedule to be laid out for the engine shop.

Aircraft-Engine Development

What few aircraft engines were in existence 20 years ago, said Mr. Cooper, the second speaker, weighed approximately 3 lb. per hp. and had a maximum output in the neighborhood of 50 hp. Now engines developing 400 hp. and having a power-weight ratio of less than 1½ lb. per hp. are available. The paper then outlined briefly the intervening steps between these two engines and mentioned the advantages of air and liquid-cooled aircraft engines. The remainder of the paper was devoted to a general description of the static air-cooled radial aircraft-engine which is the most popular and commonly used type at present.

Following this general description of the engine each individual component part was described in considerable detail with particular reference to its construction, operation and the development that has taken place in the last few years.

A general discussion followed the presentation of each paper. Among the points brought out in the discussion of Mr. Marsh's paper were the methods of breaking in airplane engines, the high efficiency obtained with European engines, the use of flexible, metal tubing, the possibilities of Diesel engines and the lubrication of engines in general.

Answering a question regarding the life of an exhaust valve, Mr. Cooper said that while engines were guaranteed to last 1000 hr. the guarantee on valves and pistons was only 500 hr. Operating an airplane in an inverted position, he said in answer to another question, calls for a special carbureter and changes in the oiling system.

In line with the policy of devoting each meeting to some particular phase of the automotive industry, oil will be the topic at the November meeting. On Nov. 20 the Section will visit the refinery of the Standard Oil Co. of California at Richmond, which is one of the largest in the world. Following an afternoon spent in inspecting the refinery, dinner will be served, after which several short papers dealing with different phases of oil refining as applied to the automotive industry will be presented.

Dayton Section Starts Season

THE DAYTON Section opened its series of monthly meetings for the winter at the Engineers Club on the evening of Sept. 26, when a dinner at 6:30 was followed by a talk by Walter J. Locke, editor of the *Dayton Daily News*, to a gathering of about 100 members and others.

Carl Kindl, chief engineer of the Delco Products Corp. and Chairman of the Section, presided and outlined the

plans for the winter, which contemplate eight monthly meetings, with speakers for the most part on matters of technical interest.

Other officers for the year are F. W. Sampson, assistant chief engineer of the Inland Mfg. Co., Vice-Chairman; G. W. Frank, mechanical engineer at Wright Field, Secretary; and A. N. Wilson, president of the Dayton Wire Wheel Co., Treasurer. The meetings will be held at the Engineers Club except when specially arranged for at other places.

Speaking on the subject of The Editor Abroad, Mr. Locke told of sights and incidents observed while he was recently on a two-weeks trip through Russia. He had the good fortune to enter the country with other persons of influence and thus was enabled to reach places of interest that are not accessible to the usual traveler.

"We think of Russia as being rather loose living, with few social restraints," said Mr. Locke, "yet I saw a case of an American being fined 25 rubles for kissing his wife in a sleeping-car compartment. The present régime is the most strictly puritanical that exists anywhere on such a large scale. A vigorous campaign is being conducted against the use of vodka through moral suasion and keeping the price high. Looseness in matrimonial relations is not encouraged, despite the fact that marriage and divorce are comparatively easy.

"But one must be loyal to the present government and if there is a well-founded suspicion that you are doing anything to injure it you are liable to face a firing squad. One morning while we were in Russia four men were shot at the instance of secret service men."

Russia was described by Mr. Locke as being a little larger than the United States, Canada, Mexico and Cuba combined, with one forest covering an area nearly as large as the United States. It has a population of 162,000,000, which, increasing at the rate of 2,500,000 a year, will give the country a population of 250,000,000 in 50 years. The country has one-third of the best productive soil of the world, but its wealth and progress rest with one-tenth of the population.

Maintenance Knocked Out

Put to Sleep in a 2½-Hour Battle of Words at Baltimore Section Meeting

BEFORE an audience of more than 90 members and guests who attended the second meeting of the 1930-1931 season of the Baltimore Section, which was held at the Lord Baltimore Hotel on the evening of Oct. 15, with a chicken dinner setting the background, Old Man Maintenance was literally flayed from pillar to post in a 2½-hr. discussion, and was left in a smoldering heap until at such time as it will again be combustible material for another interesting session.

Arthur J. Scaife, consulting field engineer of the White Co. and a member of the S.A.E. Standards Committee, was the principal speaker, presenting a paper entitled, How To Select Your Motor Equipment, which covered the subject of maintenance from the engineering standpoint and the manufacturer's side of the fence.

G. O. Pooley, Chairman of the Section and superintendent of building and supplies of the Chesapeake & Potomac Telephone Co.; Edward W. Jahn, superintendent of transportation of the Consolidated Gas, Electric Light & Power Co.; and Joseph Bavett, superintendent of maintenance of the Yellow Cab Co., delivered short discourses and presented a brief résumé of the procedures employed by their organizations in computing definite costs of maintenance. Lawrence F. Magness, president of the Hercules Power Gasoline Co., addressed the group for a short period, stressing as an all-important item in maintenance the use of high-grade oils as a means of reducing engine wear and lowering operating costs.

A. J. Underwood, director of Section activities of the parent Society, spoke briefly on the tremendous strides the local Section has made and complimented the officers on the success of their endeavors. He said that, although Baltimore is not an automobile center, sufficient interest has been shown to warrant the local body becoming one of the leading Sections in the National organization.

Uniform Record Keeping Needed

Mr. Scaife said in part:

There are no specific data or set values to aid in selecting motor equipment. Therefore consideration should be given to the type of equipment that will best fit into the kind of work to be performed. It is necessary to determine whether the loads to be hauled are heavy or light, for long or short distances and at high or low speeds. A vehicle should be of sufficient size, sturdily constructed so as to give long life, designed to give the most efficient operation and of sufficient capacity to carry the load without overloading.

We believe appearance or style to be of at least equal importance to the ability of the vehicle. With department stores a sale is never complete until the goods have been delivered and accepted by the purchaser, therefore the method of delivery of the goods is a most important factor in completing the sale. This is one of the reasons why the department stores own and control their motor-vehicle equipment, as it gives them complete supervision over the delivery system, the condition of the vehicle and the appearance of the operator.

We should realize that, to operate efficiently, it is necessary to give the equipment good care in a properly equipped place. It is difficult to get comparative costs that mean anything, as there is no uniform method of keeping records. The Operation and Maintenance Committee of the Society is now trying to devise a plan whereby a uniform system of record keeping will be used so that when comparisons are made they will really mean something.

Methods of Charging Depreciation

The rest of Mr. Scaife's paper consisted of an explanation of the proposed record-keeping system, which he said is divided into fixed and operating costs. The item of depreciation was given extended attention. This was described as "a bookkeeping device used to restore the purchase price to the account from which it was taken and to approximate the economic life of a truck, so that depreciation costs may be applied to those periods of time in which they accrue. Two logical conclusions are that (*a*) any method of depreciation used to approximate the economic life must take into consideration the factors of both time and mileage, and (*b*) an accurate determination of the true economic life must be made before any method of depreciation can be properly applied. Sound understanding of these two conclusions is prerequisite to selection of the proper method to use.

Must Find True Economic Life

Three principal methods of figuring depreciation which are most frequently used are

(1) The fixed-annual-percentage method, by which a fixed percentage of the original delivered cost of the equipment is charged off each year

(2) The mileage method, of charging off a fixed rate per mile operated, which is determined by dividing the probable life, expressed in mileage, into the original delivered cost

(3) The fixed-percentage-of-remaining-value method, of charging off each year a fixed percentage of the value left from the preceding year.

The third method, said Mr. Scaife, is a refinement of the first and is in many respects a sound one. However, an overwhelming majority of users having low mileages make use of the fixed-percentage plan. But when the accountant applies the same arbitrary percentage to all makes of vehicle and on all vehicles of the same make regardless of operation, the result is obviously unsound for cost-keeping purposes. To meet this objection, a large number of owners advocate that depreciation be charged by the mile. Either method can be used satisfac-

torily, it is believed, provided that the true economic life of the truck is carefully estimated in terms of both wear and obsolescence or both mileage and time.

The danger of unsound charging of depreciation lies not so much in the method used, according to the speaker, as in the failure to base the method on the correct economic life of trucks of different quality operating under variable conditions.

A point frequently overlooked, said Mr. Scaife, is the difference between general accounting and cost keeping. Much of the difficulty with depreciation would be eliminated if the truck owner would distinguish between depreciation he prefers to set up for general-account and tax purposes and the depreciation that represents cost and expense figures. When an arbitrary annual rate is to be used for reduction of truck investment on the general books, a second and accurately estimated rate, either for the year or by the mile and based on probable economic life, must be used for cost-keeping purposes. The maintenance department should supply the correct information to check costs accurately, if it should not actually keep the cost records.

Transmissions Considered

Free-Wheeling and Other Unconventional Types Explained at Los Angeles Meeting

SOUTHERN CALIFORNIA Section's first monthly meeting of the season attracted 160 members and guests to the dinner-meeting at the City Club in Los Angeles the evening of Oct. 3 to hear talks on free-wheeling, various unconventional types of transmission, and an unannounced surprise speaker.

As this was the first meeting of the Section since the death of Coker F. Clarkson, Ethelbert Favary spoke feelingly about the work that Mr. Clarkson had done on behalf of the Society and asked that the members assembled pay one minute's silent tribute to his memory. Mr. Favary also referred to the Council's appointment of John A. C. Warner as successor to Mr. Clarkson and of C. B. Veal as Assistant General Manager, and the members voted unanimously that Section Secretary C. N. Jacobsen write letters of congratulation to Mr. Warner and Mr. Veal and assure them of the full cooperation of the Southern California Section in the work of the Society.

The surprise speaker turned out to be Dudley Valentine, Traffic Court judge of the City of Los Angeles.

Transmissions Described and Discussed

The scheduled subject of the meeting was transmissions. The new Studebaker free-wheeling transmission was described by John E. Van Sant, general superintendent of the Paul G. Hoffman Co. Briefly, as explained, this transmission is very similar to conventional three-speed transmissions, except that the second and third-speed sliding gears are replaced by the free-wheeling unit and the second-speed gears are of the helical type.

The free-wheeling unit consists of an outer casing and an inner core, between which are three series of four rollers each that run in sloping ramps so as to form one-way roller-clutches between the core and the casing. The core is splined on the main shaft and has external dog teeth at either end that can be engaged with internal teeth on either the high-speed pinion or the main-shaft second-speed gear. The casing has internal dog teeth cut in either end, and, by shifting the free-wheeling unit, these can be engaged with the external teeth on either the high-speed pinion or the main-shaft second-speed gear.

Operation of the transmission in reverse and first speed is conventional. In normal driving, the free-wheeling unit is limited to engagement of the outer casing, which is driven through either the high-speed pinion or the second-speed gear. When the engine is driving, the hardened rollers are forced into the narrow ends of their runways and exert positive driving force on the core, which transmits the drive through the main shaft to the rear wheels. When the engine is throttled or the car speed exceeds the engine speed, the rollers are carried to the wide end of their ramps, releasing their grip.

A lock on the transmission cover limits movement of the shift lever for second and third speeds and is controlled by a button on the gear-shift knob. When it is desired to use the engine as a brake, this button is depressed, freeing the lock, and the lever is shifted further into either second or high position, so that the core of the free-wheeling unit engages, as desired, either the high-speed pinion or the second-speed gear and provides positive drive as in the conventional transmission.

Claims made for the device are that shifts from second to high speed and back can be made at 40 to 50 m.p.h. without disengaging the clutch, which need be released only preparatory to starting or reversing; that the transmission is unusually quiet in all speeds and free from clash of gears in shifting; that the engine is driving the car only about 80 per cent of the mileage covered; that stresses on the engine, transmission and axle parts and wear on the rear tires are reduced; that a saving of 12 per cent in gasoline consumption and 20 per cent in oil is effected; and that the braking power of the engine is readily available.

More Wear on Brakes

Interest in the free-wheeling transmission was made evident by questions propounded by William H. Fairbanks, of the Southern California Telephone Co.; and John Wiggers, of the Moreland Motor Truck Co. The former inquired if the brakes are not severely taxed in going down hill with the unit in free-wheeling position. To this Mr. Van Sant replied that the engine usually dissipates about 10 per cent of the power required to stop a car moving at, say, 20 m.p.h., hence there would be about 10 per cent more wear on the brakes under the condition mentioned. To take care of this, the Studebaker Corp. increased the brake area.

Mr. Wiggers asked if some States do not prohibit coasting down hill, and Mr. Van Sant responded that the driver can throw the gears into mesh if he desires, but in States that prohibit coasting some drivers break the law with conventional cars. Mr. Wiggers also wanted to know whether, when descending a hill, it is necessary to accelerate the engine if one desires to shift from third into second free-wheeling position. Although this is not necessary, said Mr. Van Sant, it is advisable to accelerate and disengage the clutch.

Other Transmissions Considered

Other types of unusual transmission described were the Syncro-Mesh, which was explained by C. A. Boom, general superintendent of the Howard Automobile Co.; the Daimler slipping oil-clutch, illustrated and described in *The Autocar* of May, 1930; the Constantinesco infinitely variable automatic transmission and several types of hydraulic transmission, described by G. L. Holzapffel; and a wabble-plate transmission developed in France, the principle of which was explained by William Bowen, of the California Institute of Technology.

Referring to hydraulic transmissions, Wendell Mason remarked that all of these must have a stationary member for increased torque, as otherwise the torque could not be increased.

Mr. Wiggers spoke of the present tendency to use more speeds in the heavier trucks. All of the larger trucks made by the company he represents are now equipped, he said, with a four-speed unit and also an auxiliary over and under-drive.

Would Increase Yearly Mileage

Good Car and Road Lighting Will Sell More Cars, Johnson Tells New Englanders

PROSPERITY and the Great White Way were linked together in an address made by W. M. Johnson, of Cleveland, commercial engineer of the National Lamp Works of the General Electric Co., before a gathering of about 125 members and guests of the New England Section at the Hotel Kenmore in Boston on the night of Oct. 10. One of the problems the motor-vehicle industry is trying to solve, he said, is to get people to drive more miles. If there were more night driving it would help to sell more cars, as the greater mileage would wear them out sooner. Many motorists feel, however, that because of glaring head-lamps they cannot see well enough to drive safely after dark, but with good lighting equipment this feeling would be dispelled. So a real opportunity exists for engineers to pay attention to proper lighting of the highways as well as the vehicles. Road lighting must be improved, and the cost is not exorbitant. With good lighting, accidents would be reduced and people would ride in comfort.

The subject of Mr. Johnson's paper was Driving at Night. Chairman Albert Lodge presided at the technical session, which followed a dinner attended by the following officers and guests and 14 members from Boston; 5 from Lawrence, Mass.; 3 from Cambridge, Mass.; and 1 each from Brookline and Watertown, Mass., and Jaffrey, N. H.:

Chairman Albert Lodge, Vice-Chairman Lewis W. Martin, Secretary H. B. Hawk, Treasurer Victor J. Ogilvie, and Committee Chairmen James A. Moyer, G. S. Whitham, and W. M. Clark, of the New England Section

W. M. Johnson, of the General Electric Co., Cleveland, speaker

A. J. Underwood, director of Section activities, S.A.E. headquarters, New York City

N. H. Wagner, Jr., and C. R. Reddick, of the Norwalk Auto Parts Co., Norwalk, Ohio

Alfred W. Devine, assistant motor-vehicle registrar of Boston, Massachusetts.

Good Lighting Reduces Accidents

Mr. Johnson, in the course of his address, remarked that lighting equipment on motor-vehicles must be adequate and easy to use, and drivers must be taught how to get the best results from it. Engineers must find out what the lighting requirements are by studying all the conditions. Drivers should have their car equipment working properly and disabuse their minds of the thought that all other users of the road are wrong. As an example of the benefit of good street lighting, he gave figures showing that the number of fatalities from accidents on two main streets in Cleveland had been reduced from an average of six per year to two by improvement in the lighting. Among common causes of accidents, he mentioned the element of surprise that causes the driver to reach for the emergency brake, such as the unexpected backing of a vehicle out of a driveway, the sudden stopping of a vehicle ahead, the "hogging" of the road and the speeder behind. Automobile engineers, he said, should study the problems of the motor-vehicle commissioners and try to help them in educating motorists.

Simple Prevention of Glare

A résumé of the great amount of research and effort that has been put upon the motor-vehicle lighting problem was given by the speaker, who said that the results are indicated by the reduction in fatalities according to the number of vehicles registered. Following the formulation of a set of standard specifications for head-lamps, it was found that the car owner will use good equipment if he can obtain it. When sufficient knowledge of the lighting requirements for safe night driving became available, the head-lamps were redesigned and the 21-cp. lamp was adopted as standard. Now the number of approved devices on the State lists has been reduced from nearly 300 formerly to less than 15 on the newer cars.

Light glare from an approaching vehicle is caused by only one thing, asserted Mr. Johnson. Although strong candlepower is needed to reveal objects nearly 200 ft. ahead, the beam must be kept out of the eyes of persons approaching. A series of tests showed that this can be done by tilting the beam downward at an agle of 2½ deg. Motorists do not generally realize, however, that the addition of one passenger in a car, or a bump in the road surface, throws the light beam 14 in. or more into the air at some distance ahead of the car.

Proper use of the dual-beam light was emphasized. Thousands of motorists, according to Mr. Johnson, make no effort to depress the beam. Lantern slides were projected on the screen to show that the lower beam gives sufficient light for at least 80 ft. ahead, while the upper beam shows distinctly objects 200 ft. ahead. The depressed beam would be used more, it is thought, if the switch for the double-filament lamps were more conveniently located. Mr. Johnson suggested that the best location is the foot or floor-boards, where it can be operated by foot; the next best place is on the steering-wheel. However, years will elapse before all the old cars and lighting equipment are replaced, and owners of these will not buy the dual-beam lamps. Head-lamps of 32 cp. are beginning to come into use, and these are as powerful as the motorists will need.

American engineers have done more, asserted the speaker, to improve lamps and lenses than those of all the rest of the world, and universally here and abroad the dual beam is regarded as necessary for safe night driving.

Solution a Matter of Compromise

Assistant Motor-Vehicle Registrar Devine, in a brief talk, said that the criticisms of the public on the head-light problem arise from the light source being placed where it is, but if the cost is to be reasonable, the lamps must be located in the particular places now used by the car makers. Solution of the glare problem is a matter of compromise between the makers and the owners. Efforts must be made to get the owner to care for the equipment and keep the lamps up to the required standard.

In opening the question period, Mr. Johnson was asked if any studies had been made of the human eye with regard to its accommodation to light by change in the size of the pupil. Mr. Johnson answered that a great deal of scientific information on eyes is

East Meets West

In recent years the Society's activities on the Pacific Coast have increased very greatly. Members in the Far Western States are very much interested in eastern automotive affairs but cannot always follow them readily. Personal acquaintance with the key members on the West Coast or a willingness to speak informally for 10 or 15 min. at West Coast Section meetings are two ways of bringing the East and the West together for mutual pleasure and benefit. If members contemplating western trips, who would like to make contacts with the western members and Sections, will forward their itinerary to the Society's Director of Section Activities, 29 West 39th Street, New York City, such information will be made available to the officers and key members of the Pacific Coast Sections.

available, but in headlighting tests many persons of all sizes were used to determine the best lighting under different conditions. He added that the eye is like a camera diaphragm, the iris adjusting itself to the intensity of light. Quantity and time are factors. Asked if any car makers are using foot switches for the head-lamps, he stated that some are but the arrangement is not very popular. He said that this is up to engineers. When asked if any particular color is better than another, he said that colored lights cut down visibility; in driving at night a shroud of light that the eye can follow through is needed.

Following the discussion, a display of the Linedol headlight tester was made.

Motorboat Development Reviewed

Lieutenant MacLean Urges Cooperation of Automobile Engineers at Canadian Section Gathering

MEMBERS of the Canadian Section, at their monthly meeting at the Royal York Hotel, Toronto, on Oct. 15, had a change of mental diet when their attention was directed to marine engineering, the speaker of the evening being Lieut. A. D. MacLean, R. N. V. R., editor of *Canadian Power Boating*, who made an appeal for the cooperation of the highly organized automotive industry in the problems that face the marine engineer.

There was a large turn-out for the meeting, at which Chairman A. S. McArthur presided. Past-Chairman Bob Combs presented some motion pictures that were keenly appreciated, and other entertainment was provided by "the Canadians," a vocal quartet, and an orchestra.

Mr. MacLean said that interest in motorboats began to develop about 1908, when the two-cycle engine, about which the automotive industry knew very little, had a great run, despite poor carburetion and faulty ignition, both overcome today. In 1914 came the great expansion of the automobile industry, which the speaker feels was a very serious factor in retarding the development and general use of the motorboat. This lull continued until 1922, when the increasing traffic on the roads turned many people's thoughts to the wider spaces on the water. Since then the industry has gone ahead, although in many cases handicapped by the lack of an engineering background.

"The automotive industry," added the speaker, "has been most kind to us, yet we need your help more and more, because most of us are working in the dark, where trained engineers could shed a lot of light, particularly with regard to stresses and strains." Mr. MacLean instanced Miss Betty Carstair's boat, the Estelle V, which made the turn in the Detroit races at 77 m.p.h., but 400 gal. of gasoline did not want to make the turn and the tank went out of the boat.

Development of the motorboat was traced from the displacement type, V-bottom and hydroplane down to the submarine-plane type. The great difficulty with the various types had been the excessive vibration in rough water. The submarine-plane type was the answer to this condition. Another type of boat, of which a great deal will be seen in future, is the submerged streamline. The success of the German ships Europa and Bremen is due, said Mr. MacLean, almost entirely to this idea, yet the merest boy knows that the best way to push a log through water is with the bulky end foremost. One of the new British submarines has an underwater speed of 16 knots, but on the surface her speed is 6 knots. It is difficult to design for both surface and underwater speed. The boat of the near future, Mr. MacLean said, will be shaped like a torpedo and carry a superstructure.

Dealing with the engines used on small boats, the speaker said that in some cases the engine is bought from a used-car lot for $10; another man goes to a motor-car manufacturer and buys an engine, ready to go into a car, for $200 and fits it on his boat. The automobile manufacturer himself sometimes takes his own engines more or less off an automobile production job, fits them with water pumps and reverse gears and sells them as marine engines. This is having an important influence on the marine industry. The high crankshaft speed of the average automobile engine makes it almost absolutely necessary, except in the smallest type of runabout, to put in a reduction gear to avoid wasting half the power. Without reduction gears the propeller speed is too high, resulting in a heavy loss in efficiency.

Discourses on Oils

Professor Baender Tells Northwest Section About Their Suitability for Internal-Combustion Engines

LUBRICATING Oils and Their Suitability for Internal-Combustion Engines was the subject discussed at the Oct. 3 meeting of the Northwest Section, held in the Arctic Building in Seattle, Wash. The speaker was Prof. F. C. Baender, of the Oregon Agricultural College at Corvallis, Ore., who had given addresses at three former meetings of the Section. Section Chairman D. F. Gilmore, of the Sands Motor Co., of Seattle, presided.

To lay the foundation for better understanding of the suitability of petroleum lubricating oils to the requirements of internal-combustion engines, the speaker first described the methods of extracting them from the crudes, dividing the refined products as marketed into (*a*) paraffin-base oils, (*b*) asphalt-base oils and (*c*) mixed-base oils. He next dealt with the properties of the refined oils and the various tests applied to measure the different properties, particularly viscosity. This, he said, usually is determined at two temperatures, 100 and 210 deg. fahr. As users of internal-combustion engines are not interested in the lubricating quality of an oil at the former temperature, an oil that shows good viscosity at 100 deg. may be a complete failure as a lubricant for an engine operating at 210 deg. or more. A blended oil may show correct viscosity at the lower temperature but when tested at the higher temperature its shortcomings will be apparent, as it will be thinned down to such an extent that it will have lost its lubricating value for the engine.

Viscosity Needed at 210 Deg. Fahr.

Oils suitable for internal-combustion engines as used in automobiles in the summer, said Professor Baender, have viscosity values of 450 to 500 Saybolt sec. at 100 deg. fahr. and 68 to 72 sec. at 210 deg. For winter use a lighter oil would be more suitable. An ordinary mineral oil of 750 Saybolt sec. at 100 deg. fahr. possesses a viscosity of about 70 sec. at 210 deg., but a patent has been issued in Germany covering a process for making an oil of high viscosity at the higher temperature. This oil is called Voltol. It is made by subjecting a light, clean mineral oil to the action of a glow discharge of a relatively high-frequency electric current, which seems to produce no other chemical effect except to greatly increase the viscosity, which goes to 240 sec. at

(*Continued on p.* 618)

Chronicle and Comment

Local Openings Propitious TWENTY-ONE Governing Boards have been busy and 21 Sections have been started along their way to a progressive year. The meetings held in October gave evidence of the careful planning that made them possible, and the programs outlined for November and succeeding months augur well for a flourishing season in every Section.

Because Section achievement and Society advancement, Society prosperity and Section prestige, are so interdependent, the parent Society is intensely gratified by the showing made by the various Sections at the opening of the new season of activity and assures all Sections of the sincere desire to furnish whatever support and encouragement may be needful to assist them in their undertakings during the year 1930-1931.

A thriving Section is evidence of an alert and interested Governing Board that is putting thought and energy and generous portions of time into the successful direction of the Section work. Even the best possible Governing Board, however, cannot do the whole job of making a Section successful. Its efforts will merely blossom without bearing fruit, unless many of the men composing the Section membership stand behind the activities launched by the officers and the other members of the several committees, showing their approval by attending the meetings. Section membership involves a genuine obligation for all concerned, but this obligation becomes not a burden but a pleasure and a distinct advantage when all members participate as they should in the Section activities.

Coker F. Clarkson Memorial PRESIDENT Warner has appointed a special committee to give consideration to the matter of a memorial to the late Coker F. Clarkson and to the form that such a memorial should take. In making this appointment he was acting in accordance with authorization voted by the Council at its meeting on July 8, 1930, the first Council meeting held after the death of Mr. Clarkson.

The members whom President Warner has asked to serve on the Coker F. Clarkson Memorial Committee are C. B. Whittelsey, Sr., Chairman; H. L. Horning, and N. B. Pope. They have consented to serve on the committee and, at the Council meeting on Oct. 9, the committee reported progress.

Section Cooperation at National Meetings THOSE who attended the National Production Meeting in Detroit last month and partook of the hospitality extended by the Detroit Section experienced genuine satisfaction in their contact with the Detroit Section. At the same time, members of the Detroit Section expressed their pleasure in being able to come into a closer and more vital harmony with the visiting members than would otherwise have been possible.

The officers and members of the Detroit Section merit the sincere thanks of all concerned for the splendid way in which they cooperated throughout the Production Meeting. In a special manner they were hosts at the Production Dinner, and it is hoped that they feel in some measure repaid for their work by the enjoyment of those who attended the dinner. Chairman Phil Kent proved himself to be toastmaster *par excellence*, in presiding at the dinner and in introducing the two speakers, John Younger, Vice-President of the Production Activity, and C. E. Wilson, of the General Motors Corp.

Other Sections have in the past made a name for themselves by the fine quality of their hospitality during National Meetings, and it is believed that such cooperation will in the future become an even more noteworthy concomitant of Section activities and Society meetings.

Many Take Part in Man-Hunt! A VERY favorable response has resulted from the item that appeared on p. 495 of the S.A.E. JOURNAL for October, entitled Man Wanted; Reward Offered. Numerous inquiries have come to the Society's office from employers seeking men, as well as from men seeking positions, and many of these inquiries have been answered by the Society to the mutual satisfaction of the parties concerned. Because of the importance of this feature of the Society's work, and on account of the interest shown in it, further remarks about the Employment Service will be found in this issue on p. 624.

More Power to Pittsburgh SELDOM if ever has the Society staged a more successful meeting than the National Transportation Meeting that took place in Pittsburgh, Oct. 22 to 24. As to quality, the papers were well above the average, and a very spirited discussion of each of them furnished a definite index of their value.

The Pittsburgh Section accomplished a splendid piece of work both before and during the meeting, and success was due in very great measure to the effectiveness of the Section members, led by Chairman John Orr. In view of the fact that "Pittsburgh" is only about a year old, its future as gaged by past and present performance is exceedingly bright.

Two Important Section Duties A BRIEF business session is to be held by each Section at its November meeting to take care of two important matters that come up each year at this season. These two matters are: the election of a representative on the Annual Nominating Committee to function during 1931 by nominating the Society's officers, except the Vice-Presidents, for 1932; and the election of a representative to serve on the National Sections Committee for the Administrative year 1931.

The representative on the Nominating Committee must be of Member grade in the Society, and it is customary for each Section to choose an alternate, also of Member grade, who will stand ready to serve if for any reason the representative finds it impossible to do so. The representative on the National Sections Committee need not be of Member grade in the Society; furthermore, it is not customary to elect an alternate for this position.

Motor-Vehicle Performance Indicating and Recording Devices

Transportation Meeting Paper

By Carl W. Stocks[1]

THE AUTHOR'S purpose is to enlist greater interest from the manufacturers in the development of more substantial instruments and to point out how these instruments can be used by all classes of motor-vehicle operators. Dividing such instruments into two groups, he sketches a background for the solving of specific problems relating to their use and then describes devices which facilitate operation. Certain instruments intended as a check on operation and designed to furnish definite information through the medium of charts or tapes are commented upon, as well as devices that are primarily designed to assist the driver in the more intelligent operation of his vehicle.

Several types of recording devices now available are analyzed, and descriptions are given which illustrate the benefits derived from their usage. The reliability of speedometers in general is doubted unless excessively expensive maintenance methods are applied to them. The author then states what other motor-vehicle carriers are doing to maintain conventional-type speedometers in reasonably good working order, on what mileage basis such instruments are overhauled, and to what extent other types of speed-indicating or mileage-recording devices are used, citing the information as obtained from a questionnaire issued by *Bus Transportation* in an attempt to secure data on the subject.

He mentions other types of instrument, including tachometers, states their advantages and disadvantages, and advocates the development and use of a device to count engine revolutions accurately, these data to be used in preference to reckon the life of an engine and its allied operating accessories in terms of vehicle mileage. In other words, the author urges the development of an accurate engine-revolution counter and the rating of engine performance by engine revolutions.

INDICATING and recording instruments for determining motor-vehicle performance are advantageous to carriers, irrespective of the class of service they operate. In this paper my purpose is to enlist greater interest from the manufacturers in the development of more substantial instruments and to point out how these instruments can be used by all classes of motor-vehicle operators. Such instruments can be classified into two groups: indicating instruments that are of value to the vehicle driver, in that they show him how he is handling his job, and recording instruments or devices for making permanent records of vehicle performance.

The more simple indicating instruments are the oil-pressure gage, the ammeter, and the air-pressure gage if air brakes are used. Then follow the speedometer, with its mileage-recording attachment, the hub odometer and the engine-speed indicator or tachometer. Recording instruments include those that are intended as a check on operation and designed to furnish definite information by means of charts and tapes.

Background for Specific Problems

The business of the motorcoach operator is, fundamentally, to produce and sell transportation at a fair price. The unit is the "ride," and the function of any motorcoach organization is to produce rides that the public will buy at the price at which rides can be sold profitably. Any other function of the motor-vehicle carrier-company is purely incidental. For example, maintenance, which I am sure all will agree is one of the most important phases of the transportation business, is in its final analysis purely an incident to the selling of rides. The many diversified problems of operation, likewise, are but other incidents. It is, however, highly important in every phase of this business that accurate records be kept. No detail is too unimportant to get by unnoticed. An exact knowledge of what is transpiring at all times within the organization is vital to its success.

Operation was formerly more or less lackadaisical and problems of checking up on the various departments were comparatively simple. The sole gage of the profitableness of operation for many of the smaller properties was the amount of cash in the carrier's bank, even so recently as five years ago. But as the motor-vehicle-transportation industry has expanded to meet the service demands, it has been necessary for the carriers to pay closer attention to the cost of their operations. To follow these trends of their business, rather complete record-systems have been developed as an essential of good management.

Not alone have these record systems been developed for the convenience of the maintenance department, for records of performance are also essential for the well-being of the transportation department. In some respects both departments are interested in the same statistics. The volume of mileage operated is of importance to all for, in some cases, it becomes the unit of pay for drivers. It is the basis in many instances for tire contracts. Mileage is also a vital factor in devising schedules for different routes; but in itself it means

[1] Editor of *Bus Transportation*, McGraw-Hill Publishing Co. Inc., New York City.

little, as gradients, volume of traffic, number of stops, and the like, also must be known.

Devices to Facilitate Operation

A transportation department is interested in devices that record vehicle-performance and that facilitate operation such as when used as a check on drivers' performance. These include (*a*) indications that trips have been run as per schedule and per hour, (*b*) grades to determine schedules, (*c*) air-brake pressures to assure safety of operation, and (*d*) speed to meet State requirements. Securing data on motorcoach movements is another phase.

The manufacturers have helped partly in the solution of this difficulty for motor-vehicle carriers through the development of certain instruments. These can be classified generally into two groups; (*a*) those intended as a check on operation and designed to furnish definite information by means of charts or tapes, the information afforded by these instruments being largely used by the executive heads of various departments and also by the record-keeping and accounting department, and (*b*) those devices that primarily are designed to assist the driver in the more intelligent operation of his vehicle. In this latter category can be included speedometers, tachometers and odometers.

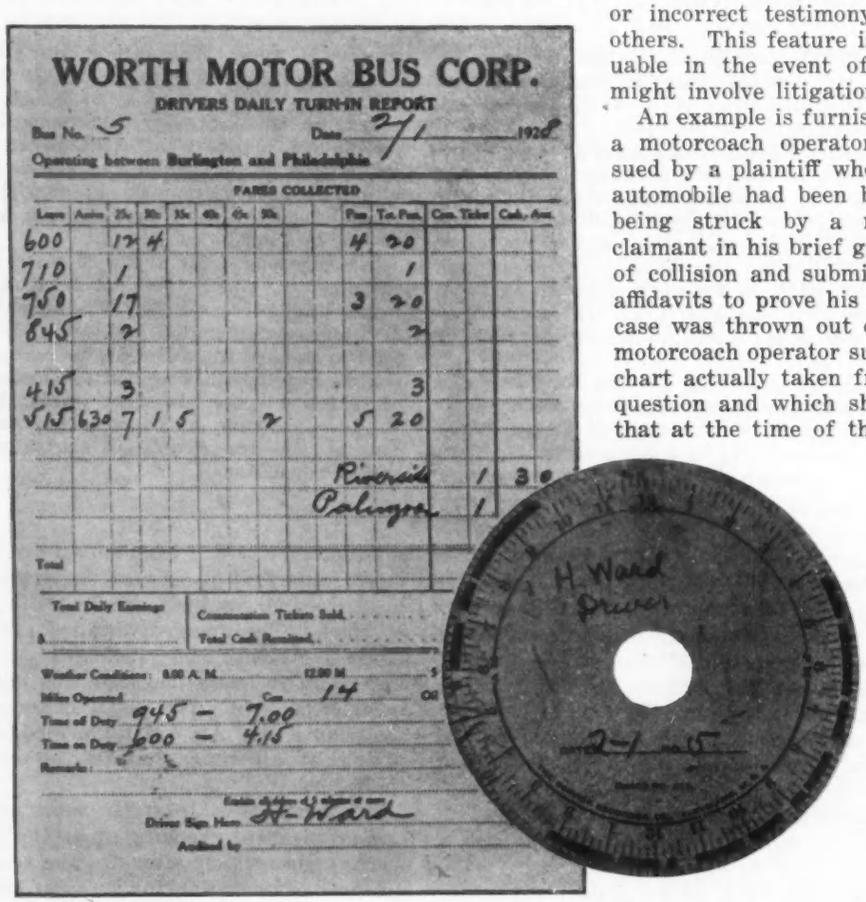


FIG. 1—CHART FROM SERVIS RECORDER, WITH REPORT TURNED IN BY DRIVER

Numerous types of the graphic recording-instruments are on the market. These range all the way from simple clock-mechanisms giving only the bare facts as to vehicle movements up to the more sensitive instruments which record vehicle-speeds and miles per hour during any interval of operation.

Aside from their more obvious uses, these performance-recording devices have three functions of particular interest to the fleet operator. Not only do they lessen the need for extensive personnel to check vehicle movements, but they serve also as regulators for the better maintenance of schedules. In addition, they make it possible to place certain kinds of maintenance work on an actual mileage-basis, thus eliminating to a large extent the guesswork and theoretical estimates of the amount of work performed. Possibly one of the most important features of instruments of this type is that their use will release for other work a portion of the men who otherwise would be required for checking vehicular movements at terminals or at points en route.

Amplifying the foregoing, recording devices can be set to give comparisons between different vehicles, routes or drivers, by showing what work was accomplished on each run. This information enables a study to be made of the effect of normal and abnormal traffic on schedules. Further, it is possible to compare trips run with schedules at all points, thereby eliminating any controversy arising from self-interest, faulty memory, or incorrect testimony of employes or others. This feature is particularly valuable in the event of accidents which might involve litigation.

An example is furnished in the case of a motorcoach operator who was being sued by a plaintiff who claimed that his automobile had been badly damaged by being struck by a motorcoach. The claimant in his brief gave the exact time of collision and submitted a number of affidavits to prove his point. The whole case was thrown out of court when the motorcoach operator submitted a graphic chart actually taken from the vehicle in question and which showed conclusively that at the time of the alleged collision the coach had been standing still for at least 3 min. prior to the time mentioned by the plaintiff. Eye witnesses testified that the coach had pulled up to the curb and was discharging passengers when the plaintiff's vehicle skidded into it. The coach operator was absolved from all claims, and in a countersuit the former plaintiff was compelled to bear the cost of repairing the coach.

With performance-recording devices it also is possible to determine whether any unusual demands have been made on a specific vehicle or whether these demands are spread out evenly over the entire fleet. Studies of this kind are invaluable in the selection of equipment best suited to particular runs.

Recording-Device Types Available

An instrument known as the "Servis Recorder," operated by a New Jersey carrier, is of the vibrator type and consists of a hinged casting with an outward-opening cover, a clock mechanism which rotates a paper dial and a winding disc that also serves as a platform for the chart itself. A lock secures the cover and pre-

vents access to the mechanism by unauthorized employes. The device can be mounted anywhere on the motorcoach and depends for action upon the movement of the vehicle.

When in operation, a needle or stylus in the upper half of the casting is actuated by a pendulum which swings when the vehicle is in motion. This pendulum marks the chart with a broad line while the vehicle is moving, and with a very fine line when the vehicle is at rest. The charts used are 4¼ in. in diameter and have 24 circumferential divisions, one for each hour of the day. These divisions are further subdivided to indicate 10-min. periods. The central portion of the chart provides space for the date, vehicle number, driver's name and operating data. The surface of these charts is covered with paraffin which is traced off by the stylus as it travels over the dial. Hence, every motorcoach movement which occurs is charted, and the company receives a complete history of vehicular performance for each 24-hr. period.

To illustrate how closely it is possible to check up on a driver, Fig. 1 is a chart from the recording instrument along with a report turned in by the driver. Note how the leaving time as shown on the driver's report tallies almost identically with the actual movement as registered on the recorder disc, which shows that the driver operated on the night run according to schedule requirements until 2:10 a.m. and returned

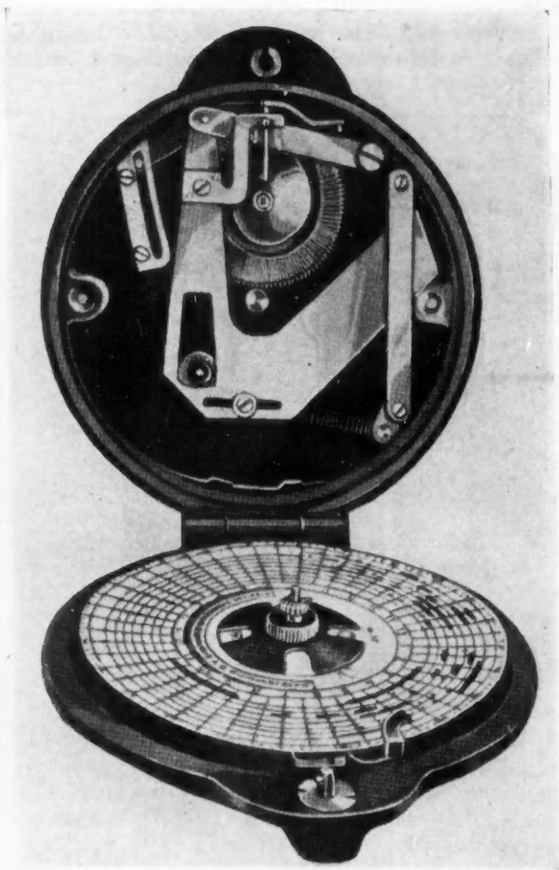


FIG. 2—THE OHMER-KIENZLE VIBRACORDER, WHICH IS A RECORDING INSTRUMENT WITHOUT DRIVE THAT CAN BE SUPPLIED FOR ONE TO SEVEN DAYS' RECORDING AND CAN BE APPLIED TO ALL TYPES OF VEHICLE

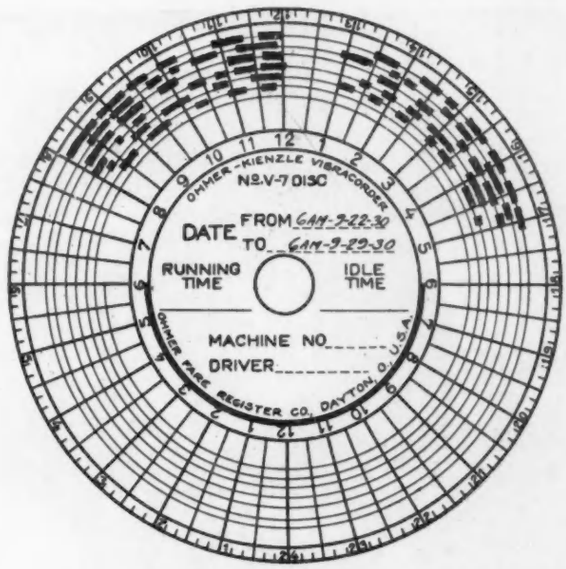


FIG. 3—A SEVEN-DAY RECORD FROM THE VIBRACORDER

the vehicle to the garage. Further vehicle-movement while in the garage is recorded between 3:40 and 3:50 a.m. by three brief "ticks" on the dial, when the vehicle was fueled, oiled and watered. At 5:00 a.m. another movement of brief duration is recorded and, at 5:40 a.m. the vehicle was lined up for the morning operation. At this time the cycle of registration was completed and a new disc was installed. It is interesting to note in connection with these charts that ordinary stops of less than 1-min. duration, such as might be made while picking up or discharging passengers, are not recorded.

An executive of a motorcoach company employing the foregoing device is very enthusiastic regarding the type of information it gives. He says: "These records have been of great value in that they indicate unauthorized stops en route and subsequent over-speeding to make up for lost time." It is particularly desirable to eliminate such tendencies, not only because of the unfavorable impression it creates among passengers but also because of the excessive wear and damage that result from this form of bad operation. Further, the recording disc shows any unauthorized movement that occurs when the vehicle should be in the garage.

The Ohmer-Kienzle Vibracorder

A somewhat similar instrument is the vibracorder, shown in Fig. 2. It can be supplied for 1 or 7 days' recording. This is a recording instrument without drive and can be applied to all types of vehicle. The instrument tells exactly the starting time, duration and end of each operation and all stoppages, supplying data for full calculation of costs. The fitting of this instrument is a matter of a few minutes once a week. Once it is fixed in a vertical position it is ready for service. The time taken for winding the clock and changing the charts is no longer than that required for setting an alarm clock.

The seven complete cycles on the chart shown in Fig. 3 represent a seven-day record. The fine line starting at 6:00 a.m. is the time the chart is placed in

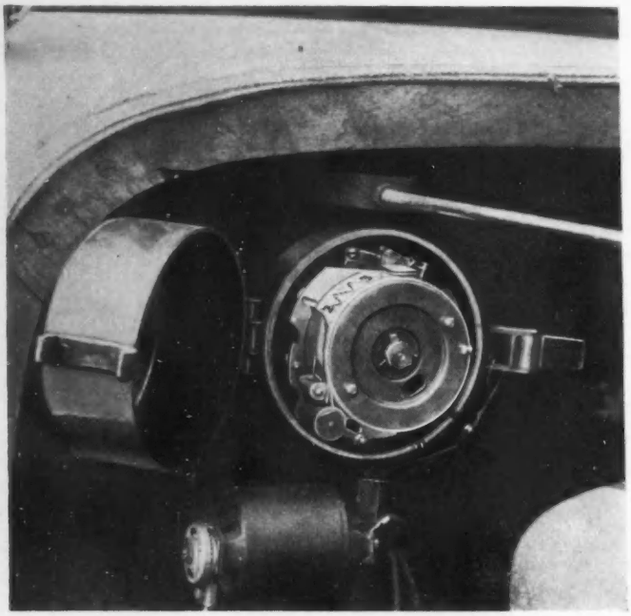


FIG. 4—THE OHMER RECORDOGRAF, WHICH IS A POSITIVE-DRIVE TYPE IN THAT IT EMPLOYS A TRANSMISSION-DRIVE MECHANISM IN CONJUNCTION WITH A CLOCK MOVEMENT AND UTILIZES PAPER TAPE IN PLACE OF A CIRCULAR CHART

the instrument. The vehicle is idle until 8:02 a.m., at which time operation is started. The operating time is indicated by the heavy line and continues until 8:45 a.m. at which time an idle period of 5 min. is indicated by a fine line. Operation of the vehicle again starts at 8:50 a.m. The vehicle operations are by this method indicated throughout the seven days, recording idle and operating time.

This record of vehicle operation is for daily periods from 6:00 a.m. to 6:00 p.m. The numerals on the inner circle represent the time from 6:00 a.m. to 6:00 p.m. or a period of 12 hr. of daytime record; and also from 6:00 p.m. to 6:00 a.m., or a period of 12 hr. of nighttime record. The numerals on the outer circle, 1 to 24, indicate 24 hr., or one complete day.

The Ohmer Recordograf

Fig. 4 shows another instrument which is similar in purpose to that shown in Fig. 2, but it differs therefrom in both its method of operation and in the nature of the data furnished. It is a positive-drive type in that it employs a transmission-driven mechanism in conjunction with a clock movement, and utilizes paper tape in place of a circular chart. It also incorporates an odometer feature. In addition to furnishing a graph of vehicular time in motion, the recordograf also charts details of speed and distance. With this information the fleet operator can determine not only the running time and the number of stops, but also the specific rate of speed for any given distance together with the hour at which the speed was made. The paper or tape used has 36 vertical divisions, each representing 1 hr. of elapsed time. Therefore, it is possible to record 36 hr. of continuous operation before replacement of the tape becomes necessary. This feature is particularly advantageous in long runs that require more than 24 hr. to complete.

Fig. 5 is a facsimile of a recordograf tape showing motorcoach movement in city service. Each hour is subdivided into 5-min. periods and horizontal rules represent distance covered. Each subdivision represents ¼ mile of travel. The vehicle movement is indicated by oblique lines, while non-movement is indicated by horizontal lines. An analysis of the record shows an operation wherein the vehicle speed averaged 10 m.p.h. with six stops per mile.

In operation, the tape is inserted on a rotating drum and a recording stylus is brought into contact therewith. As the drum rotates, impelled by the clock mechanism, the stylus draws a fine line on the paper. So long as the vehicle remains stationary, the stylus remains motionless and the resultant line is in the same plane. When, however, the vehicle is operated, the stylus is actuated by the transmission-drive mechanism so that it moves obliquely on the tape. The higher the vehicle speed is, the shorter is the time required for it to travel from one edge of the tape to the other.

The Pittsburgh Truck Recorder

The Pittsburgh truck recorder, shown in Fig. 6, is a sturdily built instrument producing a record on a 7-in. diameter chart for a 24-hr. work-day, and shows all the movements of the truck or vehicle. The record as produced on this chart is a punched record, to prevent

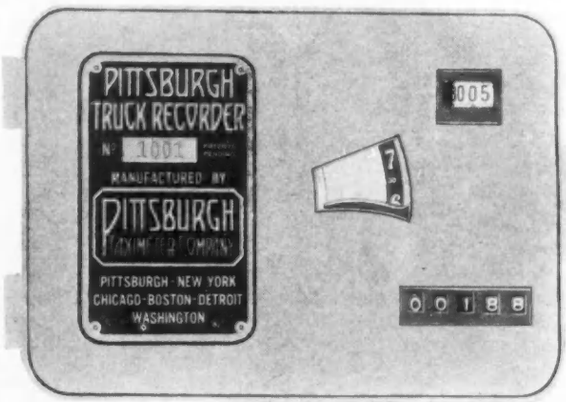


FIG. 6—THE PITTSBURGH TRUCK RECORDER, WHICH PRODUCES A RECORD ON A 7-IN. DIAMETER CHART OR A 24-HR. WORK-DAY AND SHOWS ALL THE MOVEMENTS OF THE VEHICLE

any possible forgery of the record, and the instrument can give chart records in duplicate or triplicate. The triplicate record-charts are to give a copy each to the different executives of various departments, such as the garage superintendent, the district office manager and the main office manager. Some of the facts that can be read from the chart are as follows:

FIG. 5—FACSIMILE OF A RECORDOGRAF TAPE SHOWING MOTORCOACH MOVEMENT IN CITY SERVICE

(1) Indication that trips have been run as per schedule
(2) To determine schedules
(3) Highest speed in miles per hour
(4) Average speed in miles per hour
(5) Time and duration of stops
(6) Time and duration of trips
(7) Total operating-time
(8) Total idle-time
(9) Total actual running-time
(10) Time the truck is taken out without permission
(11) Mileage used without permission
(12) Total miles traveled.

The instrument also indicates, to the driver, the accurate vehicle speed and the correct time of day. The mileage record shows the owner that the driver has not wasted gas and oil and that he is trying to reduce expenses. The instrument is mounted on the dashboard of the vehicle and is driven by means of a transmission drive, the same as for the speedometer drive. In most cases, it is only necessary to disconnect the cable from the present speedometer and to connect it to the recorder. This type of installation is very durable and will give dependable service the year round.

The Autograph Recorder

Another instrument, resembling somewhat the instruments already mentioned, is known as the autograph time and mileage recorder. It also is of the positive-drive type and, in addition to the vibrator attachment which registers running and waiting time, it also has an odometer head for recording cumulative mileage. This instrument records graphically on a paper disc. The stylus is operated mechanically through a train of gears in the clock mechanism, its operation being regulated with regard to vehicle speeds through a calibrated reduction-box attached to the speedometer outlet in the transmission gearbox, or else through a connection to the road gearbox on the front wheel. All connections are sealed to make the installation tamper-proof. This device can be mounted either on the dash panel or at some convenient position inside the body or under the hood.

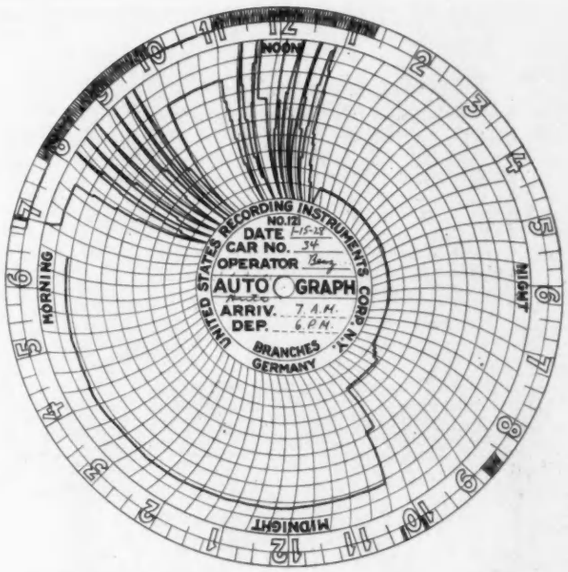


FIG. 10—TYPE OF CHART USED IN THE AUTOGRAPH RECORDER

The various operations in connection with the installation of a graph or record sheet in the autograph recorder are shown in Figs. 7, 8 and 9. In Fig. 7, the cover plate has been unlatched and the inspector or authorized employe is removing the paper disc that has been in use for the preceding 24 hr. In Fig. 8, the inspector is entering the odometer reading on the new disc which is to be installed. In Fig. 9, the fresh graph-sheet has been installed and the inspector is shown setting the stylus to register the correct time from a certain point until the following day, when the sheet will be removed. All operation is purely mechanical.

Fig. 10 shows the type of chart used in the foregoing instrument. It is 5 in. in diameter and has provision for recording elapsed time and miles operated. The former record is indicated by a series of radial lines

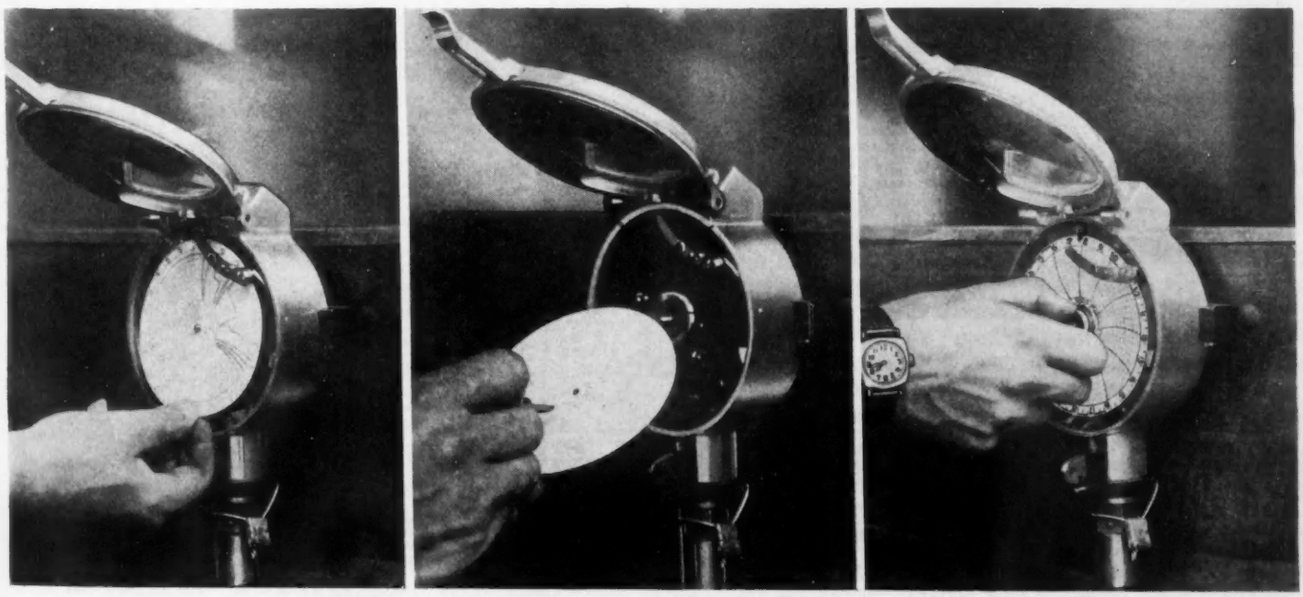


FIG. 7, 8 AND 9—THE METHOD OF INSTALLING A RECORD SHEET IN THE AUTOGRAPH RECORDER

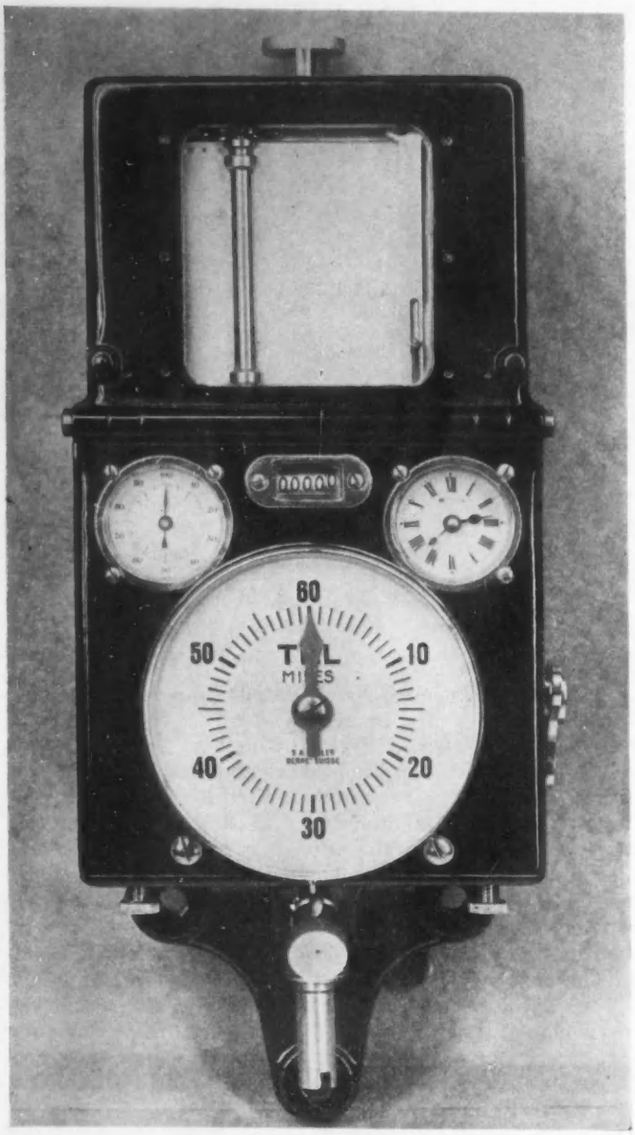


FIG. 11—THE HASLER TEL RECORDER, DESIGNED TO GIVE ON A PAPER TAPE A MORE COMPLETE PERFORMANCE-RECORD THAN THAT OF ANY OF THE PREVIOUSLY DESCRIBED INSTRUMENTS

extending from the center of the disc toward the outer circumference and in which distance between successive lines represents the passage of 10 min. of elapsed time. The chart also is marked with five concentric divisions to signify mileage, each division therefore representing ½ mile of travel. In operation, the chart is slowly rotated by a clock mechanism. The stylus, actuated as previously explained, is caused to move over the face of the chart and traces thereon a record of its movement. This recorded movement, in turn, can be translated into terms of vehicle operation; a radial movement indicates miles traveled and a cycloidal movement signifies that a stop has been made.

The Hasler Tel Recorder Described

Another and somewhat different type of instrument for furnishing effective and reliable means for the control of operation and the supervision of vehicles is offered in the Hasler Tel Recorder, for motorcoach use. It is a European product which has found limited use in the United States due, no doubt, to its cost, which is $300.

Fig. 11 shows the Hasler recorder, it being designed to give a more complete performance-record than that of any of the instruments described previously. The record is made on a paper tape, a part of which is shown in the rectangular opening at the top of the instrument. It is said to be complete in function, accurate in operation, direct in its recording and reliable in severe service. It can be installed on any vehicle having a speedometer driveshaft, and furnishes a permanent record of operating data, such as: vehicle speeds attained during every second of operation; time and duration of runs and of stops; location of stops on a mileage basis; total operating time, whether the vehicle is moving or standing and when; trip mileage, total mileage, and an indication to the driver of accurate vehicle-speeds and the correct time of day. Such records, in addition to their importance in operation, also provide valuable information in connection with the investigation of accidents, delays and the like.

Fig. 12 shows a sample chart from a motorcoach on a suburban line running on a 70-min. service over a 25-mile route, with a 5-min. layover at each end and a prescribed speed-limit of 35 m.p.h. The main points of interest are marked *A*, *B*, *C*, and so on, which are translated in the following tabulation:

LOG OF ONE-WAY TRIP

	Time	Stops	Speeding, M.P.H.	Mileage
(*a*)	11:45	End, outbound trip	..	..
(*b*)	11:50	Start, return trip	..	..
(*c*)	12:01	Stop, 15 sec.	..	3
(*d*)	12:03	Stop, 2 min.	..	3½
(*e*)	12:07	Stop, 40 sec.	..	4½
(*f*)	12:09	Stop, 1 min.	..	..
(*g*)	12:11	Stop, 10 sec.	..	5½
(*h*)	12:14	Sudden stop	..	6
(*i*)	12:30	.....	42	9
(*j*)	12:23	.....	40	10½
(*k*)	12:26	.....	37	12
(*l*)	12:29	Stop, 1 min.	..	13
(*m*)	12:31	Stop, 30 sec.	..	13½
(*n*)	12:35	Stop, 30 sec.	..	15
(*o*)	12:41	.....	41	18
(*p*)	12:43	.....	40	19
(*q*)	12:44	.....	39	19½
(*r*)	12:46	Stop, 30 sec.	..	20
(*s*)	12:48	Sudden stop	..	21
(*t*)	12:56	Stop, 1 min.	..	23½
(*u*)	12:59	Stop, 30 sec.	..	24
(*v*)	1:01	Stop, 30 sec.	..	24½
(*w*)	1:02	Stop, 10 sec.	..	..
(*x*)	1:03	End, inbound trip (3 min. late)		25
(*y*)	1:08	Start, outbound trip	..	..

A summary of the foregoing data as available for the operating department would be as follows:

OPERATING DEPARTMENT; SUMMARY OF LOG DATA

(1) Start, in-run, on time.
(2) End, in-run, 3 min. late.
(3) Time, run, 73 min.
(4) Actual running-time, 64 min.
(5) Number of stops, 15.
(6) Total duration of stops, 9 min.
(7) Over-speeded, six times.
(8) Total time, over-speeding, 4 min.
(9) Maximum speed, 42 m.p.h.
(10) Average speed, 23.5 m.p.h.
(11) Schedule speed, 20.6 m.p.h.
(12) Trip mileage, 25 miles.
(13) Stopping time, 11 per cent.
(14) Running time, 89 per cent.

In the foregoing text, I have attempted to select only those instruments that are typical of a particular class without any specific inference as to their ability to compete with other instruments of similar design. The other group, those designed to assist the driver in the more intelligent operation of his vehicle, include

speedometers, tachometers and odometers, ammeters, air-pressure gages and the like, which will now be discussed.

Speedometers, Tachometers and the Like

At the American Electric Railway convention in Atlantic City, N. J., in October, 1929, the subject of speedometers was discussed by motorcoach executives. An official of a large public-utility company in Maryland mentioned that, in a recent State inspection of motorcoaches, only seven vehicles out of a total of 87 had speedometers that were in working condition. This was only about 8 per cent of the fleet. In Maryland, State regulation requires the use of a speedometer and this particular executive was most anxious to find some solution to his problem. In the ensuing discussion, it seemed to be generally agreed that speedometer maintenance was a more than casual problem in most operations.

Bus Transportation recently attempted to gather additional statistics on the subject through the medium of its consulting department, a question-and-answer section largely devoted to the interchange of information on problems that affect the industry in general. The following questionnaire was sent out to about 50 motor-vehicle-carrier executives and about 30 replies were received.

> What are other motor-vehicle carriers doing to maintain conventional type speedometers in reasonably good working order? On what mileage basis are such instruments overhauled? To what extent are other types of speed-indicating or mileage-recording devices used?

The replies to this questionnaire are given in full in the July and the August, 1930, issues of *Bus Transportation*. I will summarize the opinions expressed and bring out the points that were mentioned in some of the letters. An excerpt from a letter received from the executive head of one of the largest motorcoach-operating companies in Pennsylvania reads as follows:

> Speedometer maintenance is a serious problem with all maintenance men today. Maintenance of these units is entirely too expensive at best and speedometer manufacturers should be urged to develop more durable speedometer equipment.

Another motor-vehicle carrier writes as follows:

> We make no effort to maintain speedometers. We find such maintenance to be a waste of effort and money. Regardless of the amount of care given these instruments, we have never received satisfactory results.

Still another superintendent of one of the largest city-service companies in Ohio says:

> We have stopped trying to keep speedometers in working condition. After seven years, we have found there is no way to set a definite date or mileage as to when overhauls should be made so as to eliminate trouble and feel certain of results. A new speedometer or rebuilt instrument is just as likely to give trouble as one that has been in service for some time.

A letter from a carrier in Massachusetts says:

> We have had a great deal of trouble with speedometers, particularly with the cables and gears. Speedometer heads seldom give any trouble, especially the new ones purchased within the last two years in which the bearings are set in jewels. All of our motor-vehicles are fitted with hub odometers, the data from which are used to make up our mileage and inspection records.

One of the largest companies in Michigan, in pointing out some of the difficulties involved, says:

> We have twelve different lengths of speedometer cables, and housings ranging from 13 in. to 23 ft. long, with seven different-type cable-tips. We have found it advisable to attempt to keep this equipment in repair, our average monthly expense for speedometer repairs being $25 for a fleet of 550 motorcoaches. On 40 of our street-car-type vehicles, speedometers are not provided; but a mileage-recording device is located near the rear door of the body. The cable for this instrument is 32 in. long and, naturally, it wears much better than the longer cable. We also have 50 motorcoaches each of which is equipped with a recording instrument in addition to the conventional speedometer.

Another operator of a good-sized fleet in Western Pennsylvania writes:

> We do not try to keep speedometers in repair because, to date, no manufacturer has made an instrument which will stand up in motorcoach operation. We have vehicles on the property in which the speedometers ceased to function before the vehicle had operated 1000 miles.

Another Ohio carrier says:

> We have not yet found a speedometer on the market which is accurate or dependable for any length of time. Some manufacturer has a great opportunity to produce a moderate-priced mileage-

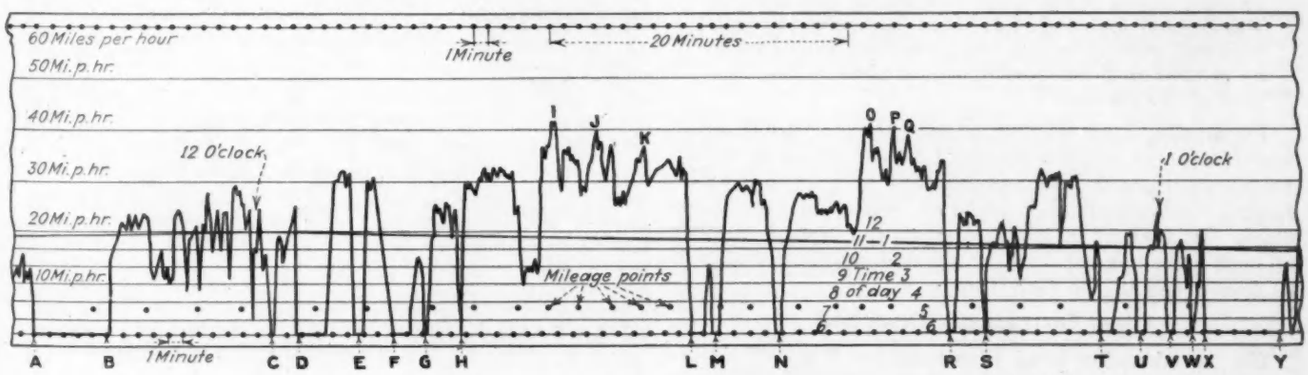

60 Miles per hour
50 Mi. p. hr.
40 Mi. p. hr.
30 Mi. p. hr.
20 Mi. p. hr.
10 Mi. p. hr.
1 Minute
20 Minutes
12 O'clock
1 O'clock
Mileage points
A B C D E F G H L M N R S T U V W X Y

FIG. 12—A SAMPLE CHART FROM THE MOTORCOACH RECORDER SHOWN IN FIG. 11

recording device which will be accurate and dependable. I am sure that all motor-vehicle carriers would appreciate such an achievement.

A manufacturer of speedometer equipment has this to say:

Operators that complain of their inability to keep their speedometer equipment operating are fully

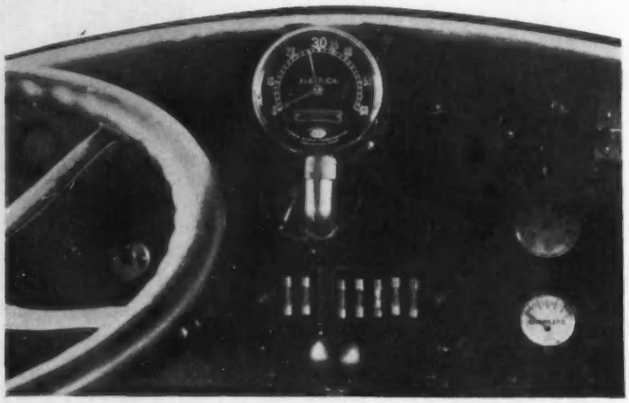


FIG. 13—A SPEEDOMETER HEAD DESIGNED TO INDICATE MAXIMUM SPEEDS AT ANY TIME DURING A RUN

justified in many cases. This is due, however, to the fact that the speedometer equipment used was never designed for motorcoach use and really is intended for passenger-car use only. Many of these instruments have spur gears mounted on the propeller-shaft driving a fiber pinion attached to the swivel joint. Such equipment has long since been considered entirely inadequate even for passenger-car service.

The transmission type of drive is the only type that is practical for passenger-cars and motorcoaches, and all motorcoach manufacturers who have given this careful consideration have adopted this type of drive. Even where the transmission type of drive is used, many of the failures are due to shaft cable breaking owing to its operation through bends of too short radius. It is unfortunate that not all motorcoach manufacturers and operators have given proper attention to the layout of the shaft installation so as to assure uninterrupted service. This must be laid out carefully, since no radius of less than 8 in. will assure freedom from cable breakage. Shafts also should be greased every 1000 miles.

As to speedometer failures, a number of these even on the ordinary passenger-cars could be avoided if the motorcoach operator would see to it that these speedometers are properly cleaned and relubricated at least every 20,000 miles. Often we find that the speedometer and shaft have been allowed to run until they fail without having been given any consideration as to their need for lubricants, the same as the other part of the chassis.

Personally, I am of the opinion that if speedometer manufacturers would work more closely with the motor-vehicle carriers it would be possible to develop a satisfactory instrument that could be sold at a reasonable price. In fact, it is my understanding that a number of such developments are at present pending and will be announced in the near future.

Other Instruments Described

The speedometer head illustrated in Fig. 13 represents a development that has been worked out by a large-scale motor-vehicle carrier in New England, in collaboration with a speedometer manufacturer. One of its main features is a pusher needle arranged to indicate maximum speeds at any time during a run. For example, if the driver operates his motorcoach at 30 m.p.h. and then drops back to 20 m.p.h., the maximum-speed hand will remain at the 30-m.p.h. point on the dial. If the operator speeds his vehicle to a point beyond the 30-m.p.h. indication previously made, the needle will follow up to this point and will remain there until a still higher speed is attained.

The particular motorcoach operating-company that uses this device has set 35 m.p.h. as the maximum road-speed to be permitted. If a driver should turn in his motorcoach and the maximum-speed hand showed that the 35-m.p.h. point had been exceeded, he is liable to censure and possible discipline. The object is to prevent the driver from operating his vehicle beyond a reasonable speed. The only disadvantage that I see with this type of instrument is that no provision is made to register the number of times over-speeding occurs, nor is there any way of detecting whether the driver has operated his engine at excessive speed in low gear.

Another example of the way in which motor-vehicle carriers are attempting to cooperate with the manufacturer is illustrated in the case of a Canadian operator who has collaborated with a manufacturer in the development of a new instrument primarily designed to curb the tendency to over-speed, particularly along unpatroled highways. The instrument is a special speedometer which gives both audible and visual warning when the vehicle is operated above a predetermined speed. It also registers the number of times this over-speeding has occurred. The latter feature, company officials hold, is particularly valuable in that it gives an accurate check on operation.

Fig. 14 shows the face of this instrument, which contains a clock-like mechanism which functions both as a

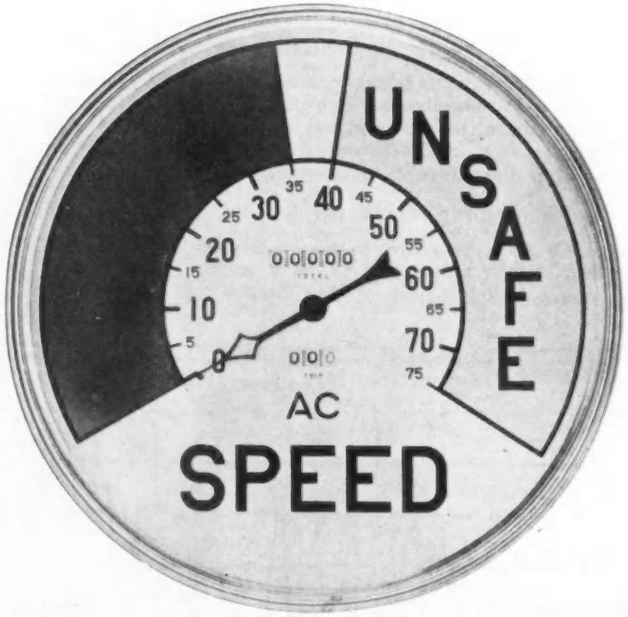


FIG. 14—AN INSTRUMENT CONTAINING A CLOCK-LIKE MECHANISM WHICH FUNCTIONS BOTH AS A SPEED INDICATOR AND AS A WARNING TO THE DRIVER. THE SECTOR FROM 0 TO 35 M.P.H. IS COLORED GREEN; THAT FROM 35 TO 40 M.P.H., YELLOW; AND THAT FROM 40 TO 75 M.P.H., RED

speed indicator and as a warning to the driver. The mechanism is driven by a standard speedometer-cable hook-up. The dial face is unusually large, being 8 in. in diameter. The instrument is mounted in a conspicuous place on the dash. The outer circle of this dial has been blocked off into segments colored green, yellow and red. The green portion coincides with speeds up to 35 m.p.h., the provincial legal speed-limit; the yellow portion with speeds from 35 to 40 m.p.h.; and the red with speeds in excess of 40 m.p.h. So long as the indicator points to the green portion, the coach is considered as proceeding at a proper speed, the yellow is supposed to represent a 5-mile range between speeds which still can be considered suitable and those which are looked upon as excessive. When the indicator passes the red mark at 40 m.p.h. a bell inside the coach rings until the speed is brought below the maximum. The mechanism permits the maximum speed-limit to be set to suit any desired operating-range. This adjustment, however, is accessible only to properly authorized employes. Each time the speed limit is exceeded an electric solenoid registers on a small consecutive-number recording-device. For example, if at the beginning of a trip this meter registers 280 and the driver exceeds the speed limit five times, the meter shows a total of 285 at the end of the trip.

Inspection Schedule for Speedometers

It is common knowledge that speedometers need frequent attention and that it is necessary to put them on a definite inspection-schedule for change-off and overhauling if service failures are to be reduced to the minimum. Is it any wonder if the disgruntled maintenance man finally passes up the speedometer as a bad job and devotes his attention to more important work? Due to the conditions previously mentioned, speed-indicating instruments on a great number of motorcoaches are more or less permanently out of commission.

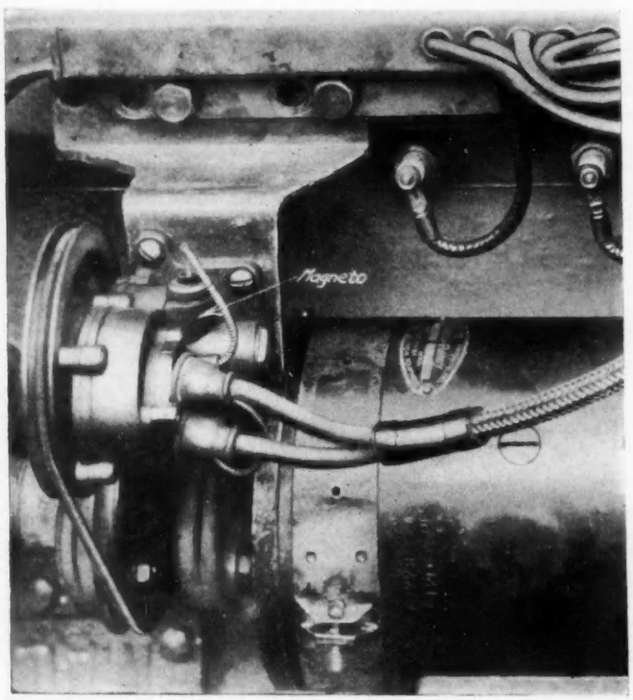


FIG. 15—HOOK-UP OF THE TACHOMETER INSTALLED FOR THE INITIAL EXPERIMENT ON A STANDARD PASSENGER-CAR

FIG. 16—TACHOMETER HEAD USED IN THE FIRST EXPERIMENT, BEING A DIRECT-CURRENT VOLTMETER CALIBRATED TO READ IN REVOLUTIONS PER MINUTE INSTEAD OF IN "VOLTS"

Use of Tachometers Discussed

Because of these conditions, maintenance men are beginning to look with favor on tachometers. Some time ago the superintendent of a motorcoach operation in Ohio found out that H. P. Sparks, of the Westinghouse Electric & Mfg. Co., was working on an electrical speed-indicator for steam locomotives. He believed that it could be applied with little difficulty to motorcoaches and, through the cooperation of the Westinghouse company, the following experiment was made possible.

The Westinghouse company supplied the necessary equipment and the motor-vehicle carrier furnished the vehicles upon which tests were to be made. The first experiment was with a standard automobile that was being used in every-day service. The test proved so successful that other tests were made later on a Fageol motorcoach operating at normal highway-speeds over an intercity route of moderate length. Based on the results of this second experiment, sufficient additional data were obtained to warrant the belief that such equipment might be the solution of the problem of speed-indicating instruments for motorcoaches.

Fig. 15 gives an idea of the hook-up of the tachometer as installed for the initial experiment on a standard passenger-car. It comprises a magneto securely bolted to the engine frame and mechanically driven through a coiled spring-wire belt from a pulley mounted directly on the crankshaft. The speed and the voltage output of this magneto, when plotted, form a curve which, for commercial purposes, is practically a straight line. It is possible, therefore, to measure accurately the electrical energy developed and to translate it into terms

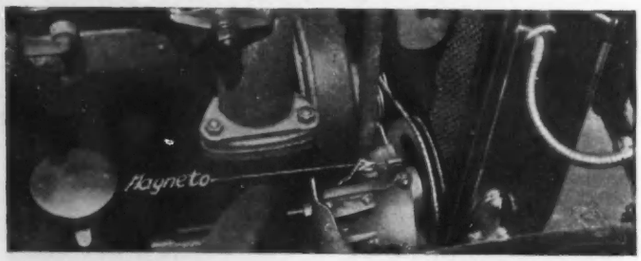


FIG. 17—MAGNETO ATTACHED TO A SPECIALLY DESIGNED BRACKET AND MOUNTED DIRECTLY ABOVE THE FLEXIBLE COUPLING ON THE PUMP SHAFT

of engine revolutions. For purposes of measurement, a standard direct-current voltmeter is used, with a dial face graduated for engine speeds up to 4000 r.p.m.

The tachometer head used in the first experiment and shown in Fig. 16 is a direct-current voltmeter calibrated to read in revolutions per minute instead of in "volts." This indicator is mounted on the steering column, and has armored-cable connection to the magneto. In the first installation, two special red marks were placed on the dial; one was to indicate the maximum safe operating-speed while the engine is cold, and the second was to indicate the maximum engine-speed for full horsepower output. The car then can be operated so that the engine will warm up before exceeding the first red mark at 1500 r.p.m. After the engine has warmed up, it can be brought up to 3200 r.p.m. either in low or second gear without serious injury to the moving parts. Maximum horsepower, which in this case develops at 3200 r.p.m., gives a road speed in high gear of slightly more than 60 m.p.h. Because of the character of information supplied by this tachometer, correct engine-operation is possible at all times. Further, the instrument is of value to the driver when negotiating steep grades or when attempting to get the motorcoach under way quickly.

The foregoing electrical tachometer, as applied to the standard passenger-automobile, had operated to Jan. 1, 1930, more than 35,000 miles without any attention; not even an adjustment of the bearings was necessary, nor was the magneto mechanism oiled. The initial experiment proved so satisfactory that it led to the belief that an electric tachometer driven either from the crankshaft or the auxiliary shaft of a motorcoach engine could be calibrated and used to indicate road speeds in high gear, with sufficient accuracy for all practical purposes.

An intercity coach was therefore fitted with an instrument of this type for the second experiment. It had the voltmeter calibrated to read in miles per hour instead of engine revolutions per minute. When the magneto was first installed, it was driven by a V-type leather-belt from the engine pump-shaft. This proved impractical, as the belt whipped off the pulleys and would not stand up in service. Direct drive was employed next, using a micarta gear with a cast-iron driving-gear mounted on the flanged coupling of the auxiliary shaft. This method of drive operated successfully until the gears stripped as a result of severe service. Naturally, the magneto was wrecked.

A third installation made employed a coiled spring-wire belt-drive. At first a belt of the same diameter as the pulley groove width was used, but this failed in two ways; not only did it have a tendency to jump out of the pulley groove but it set up harmonic vibrations. Further, the belt whipped and slipped so much that it affected the accuracy of the instrument. Coiled-wire belts of a smaller cross-section than the pulley groove then were tried until satisfactory operation was secured. It was possible practically to eliminate belt slippage and to get completely away from the whipping action which previously had caused so much trouble. This type of installation has now operated about 175,000 miles without trouble.

Tachometer and Magneto Mounting

Fig. 17 shows the magneto attached to a specially designed bracket and mounted on the engine directly above the flexible coupling on the pump shaft. A pulley is inserted on the flexible-coupling mechanism with its trued faces supported by the pump shaft and held away from the floating flexible coupling. A special flanged-spider on the pulley simplifies the installation. The coiled spring-wire driving-belt now used is adjusted so that it is under tension at all times irrespective of the speed of operation.

Fig. 18 shows the tachometer head and rheostat as used in calibrating this instrument. The calibrations in miles per hour obviously are accurate only for high-gear performance. The instrument can be calibrated accurately by means of an adjusting rheostat as shown at the right, and takes care of changed conditions due to tire wear or changes in the rear-axle reduction-ratio. Because the output of the magneto is practically constant for a given engine-speed, the rheostat is used merely to regulate the amount of current flow to the voltmeter. While this experimental design has been in service more than a year, very little maintenance has been necessary. On one occasion a belt jumped its

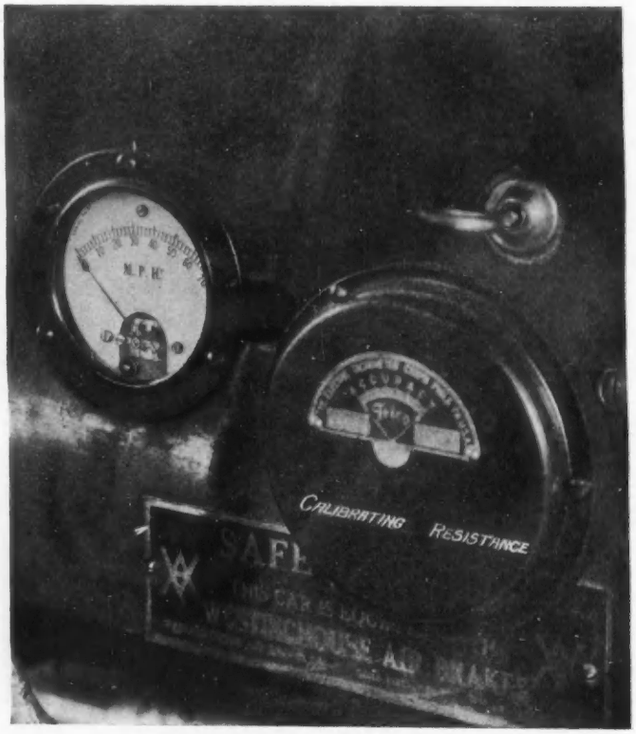


FIG. 18—TACHOMETER HEAD, AND RHEOSTAT USED IN CALIBRATING

pulley and was lost. This, however, was one of the belts of larger diameter. Since then the small-sized belt has given excellent service, and still remains on the coach after more than a year's operation.

Electric-Tachometer Difficulties

The main difficulty in using an electric tachometer lies in the fact that there is no provision on the standard motorcoach engine for attaching the apparatus. It seems to me that the engine manufacturer needs sooner or later to recognize this, as has been done in the airplane industry where standard practice makes provision for the fitting of a tachometer drive. To those who are interested in the possibility of this development, care must be used in the selection of the proper size and type of belt, in drawing the belt to the proper tension, and in determining the proper diameter for each particular make of vehicle. All of these points must be taken into consideration and carefully worked out before the application is made. If this is done, there is no important reason why the electrical type of speedometer cannot be applied to present-day motorcoaches.

Another thing to consider is the design of the magneto itself; it should be substantial, to withstand belt-strain. The one used in the test mentioned is fitted with ball-bearings of the annular type. It required very little attention in service. In fact, not even oil holes are provided for lubrication. Other than the belt drive, there are no mechanical connections; all others are electrical. The connection between the voltmeter and the magneto is a special armored cable insulated to withstand the effects of grease, dirt and heat. The rheostat provides means for adjusting or calibrating the tachometer without removal from the coach. In other words, the operation of the apparatus is entirely electrical and uses only the simplest possible type of mechanism.

In my opinion, provision should be made for tachometer installation on the engine. A transmission installation could be provided in the event that the number of revolutions of the engine is not considered of sufficient importance. The latter installation would permit direct reading in miles per hour in any gear position, the same as is now furnished by the conventional speedometer. Generally, it seems that the preference is for the recording of engine speeds rather than that of road speeds. The possibility of providing means for pad mounting of the magneto on the engine or transmission is a point which coach operators also should consider when purchasing new equipment.

At present, a number of tachometers are on the market, being of the electrical type just described and of the purely mechanical type in which centrifugal weights are employed. Both devices are being tried out by motor-vehicle-carrier operators but data on the results obtained are insufficient as yet.

Engine-Revolution Counter

A development which is being brought about largely through the interest of *Bus Transportation* is an instrument to count engine revolutions, as shown in Fig. 19. I consider the development of such an instrument to be imperative because, up to the present, the motor-vehicle carrier has been compelled to reckon the life of the engine and its allied operating accessories in terms of motorcoach miles. Unfortunately, mileage is wholly inadequate for this purpose. As every maintenance man knows, the relation between mileage and actual engine-performance is highly variable except in high-gear operation or in the case of the gasoline-electric power-unit where the engine speed is fairly constant under ordinary operating conditions. Further, with this latter type of propulsion, it is possible to measure engine work performed in terms of kilowatt hours. There is no such meter for the straight mechanical drive. The only one that approximates it in any way is the fuel recorder.

As a basis for inspection and overhaul or for measuring motorcoach performance, the number of miles operated is accurate only when the unit to which this standard is applied receives approximately the same amount of service irrespective of road speed. This is true whether the vehicle is traveling at 6 or at 60 m.p.h. Tires, axles and all operating parts of the drive-line forward to the gearbox come in this class. All of these units can be said to have an invariable operating characteristic so far as mileage is concerned. The power-plant and its related parts, on the other hand, can be made to do more or less work per mile through the

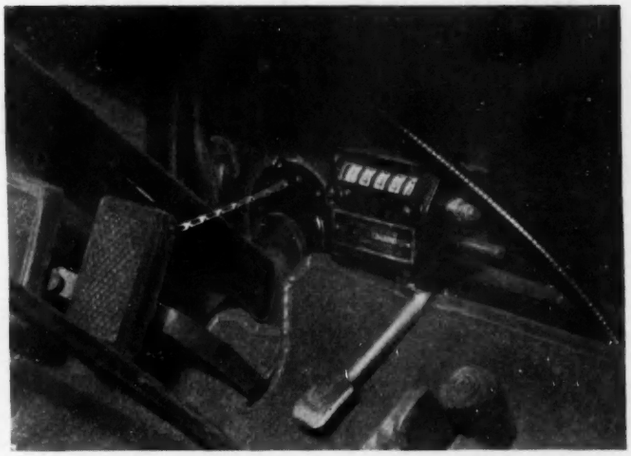


FIG. 19—AN INSTRUMENT TO COUNT ENGINE REVOLUTIONS, A DEVELOPMENT LARGELY DUE TO THE INTEREST OF *Bus Transportation*

various gear reductions in the transmission. We all know that it is even possible to wear out a brand-new engine completely and reduce its component parts to scrap without moving the vehicle in which these elements are mounted one single inch. This may seem like a far-fetched example, but it serves to illustrate the unsatisfactory measure with which maintenance men have been compelled to gage the performance of the motorcoach engine.

Tire or wheel mileage as a basis for engine maintenance and inspection fails to make proper allowance for operation in gearset positions other than high gear. Then also, idling, which accounts for a good-sized share of engine operating-time, particularly over routes in city service cumbered with heavy vehicular-traffic, has been disregarded entirely. Again, in those cities where heavy grades must be negotiated in gear—both ascending and descending—or where abnormally heavy traffic is encountered, gear work may amount to 50 per cent of the total running-time. In city operation, this figure varies between 10 and 32 per cent, according to data furnished by several motor-vehicle carriers. Under

TABLE 1—ACTUAL EXAMPLE OF HEAVY-TRAFFIC OPERATION

Details	Elapsed Time, Min.	Total Engine Revolutions
(1) Traffic-light stops, with engine idling at approximately 300 r.p.m.	6	1,800
(2) Passenger loading and unloading, with engine idling at approximately 300 r.p.m.	2	600
(3) Gear operation in first and second speeds with engine speed estimated at approximately 2000 r.p.m.	4	8,000
(4) High-gear operation with engine speed estimated at 1500 r.p.m., or 15 m.p.h.	8	12,000
Total	20	22,400

these conditions, any attempt to use mileage comparisons between vehicles operating day after day in heavy traffic with other equipment used on routes where practically all operation is in high gear, obviously will be unproductive of satisfactory results.

As an illustration, some time ago a motor-vehicle carrier complained to a manufacturer of electrical equipment that a generator on one of his motorcoaches failed at 35,000 miles, while another unit of similar make and type was still giving a good account of itself at the end of 50,000 miles. A check by the manufacturer's representative showed that the former unit, up to the time it failed, actually had given about 20 per cent more service than the unit which the motor-vehicle carrier had praised. Both generators had been serviced and lubricated at similar mileage-intervals, so that the first unit had been "starved" while the second had received attention too frequently. This is cited as only one of many instances in which the amount of service rendered by a unit is not in proportion to the actual motorcoach mileage operated. Greater recognition of idling and low-gear operation would obviate this trouble and put maintenance and inspection of the powerplant on a more equitable basis.

Suggestions have been made that motorcoach-engine maintenance be placed on a "service-hour" basis similar to the practice followed in aerial transportation; but proponents of this scheme lose sight of the fact that the airplane engine operates at constant speed, or one-half throttle, about 90 per cent of the time. Idling and full-throttle operation are only of minor consideration, while gear work is a factor with which the aviator need not reckon.

Performance Rated by Engine Revolutions

What can be done, then, in the development of more suitable means for measuring the actual work performed by the motorcoach engine? The only practical solution, it would seem, is to use engine revolutions as the unit of measurement. To illustrate this idea, consider as an example two motorcoaches of similar make and design, operated in city service over routes of similar length or say 2½ miles each. Operating conditions of these two routes are widely dissimilar. One route is comparatively free from grades, has little or no contending vehicular traffic and requires but few service-stops. Practically the entire trip can be made in high gear, so as to maintain an average road-speed of 15 m.p.h. With proper allowance for service stops, gear operation and idling, the total number of engine revolutions rolled up on a trip of this character might be estimated conservatively as 15,000. In each of these cases it is assumed that the engines are in substantially the same mechanical condition.

The second motorcoach was operated through heavy contending vehicular traffic over a route having a number of steep grades. Traffic lights and frequent stops complicate the problems further. The average schedule-speed of this route is 7½ m.p.h. so that twice the time, or 20 min., is required to make the trip. Under these conditions engine operation for the run might be estimated at 22,400 revolutions. In making this estimate the conditions in Table 1, based on repeated observations have been assumed.

Assuming that both engines are inspected and serviced at 1000-mile intervals, the first unit will have accumulated a total of 6,000,000 revolutions, while the second will have rolled up 8,960,000 revolutions, a difference of substantially 50 per cent. In other words, engine No. 2 has given the equivalent of 1500 miles of service although speedometers or route data show but 1000 miles. Is there any wonder that there is a marked difference in vehicle performance when mileage is used as the standard of measurement?

Engine-Revolution Counter Needed

There are other advantages in using engine revolutions to measure performance. Not only would this medium furnish a true gage of service life for cylinder-blocks, crankshafts, bearings, valves, pistons and other wearing parts, but it also could be applied to operating accessories including the air-compressor, generator distributor, carbureter and spark plugs. Before it is possible to take advantage of the system suggested, it will

(*Concluded on p. 552*)

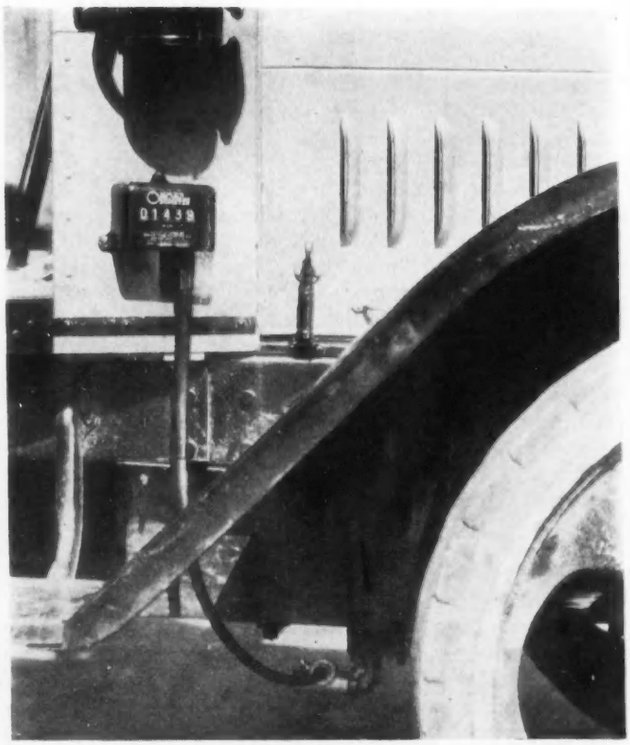


FIG. 20—ODOMETER FOR RECORDING THE NUMBER OF REVOLUTIONS OF A MOTOR-VEHICLE ENGINE

Economic Motor-Transport Instruction

Transportation Meeting Paper

By Prof. James W. Trimmer[1]

Sketching motor-vehicle-transportation development, since the World War, inclusive of the large fleets of passenger and freight vehicles operating both locally and across country, the author says that we have seen automotive transportation grow from a local institution into a nation-wide one and automotive transport relieve the short-haul problem of the railroads, expanding into long-haul traffic for perishable goods and into motorcoach traffic for passengers.

The executive personnel with experience along transportation lines naturally was drawn from the steam and the electric railroads; but while it is true that its members had wonderful training in the handling of passengers and freight, and in meeting with officials of State and Federal regulatory bodies, they did not have the knowledge, training or experience for handling the independently operating self-contained motor-vehicle with its many and unique problems. The operating personnel had to be found and trained. How was it to be trained and along what lines was this necessary training to be given? The motorcoach operator had to have the qualifications of a salesman, conductor, driver and mechanic and, in addition, certain physical and mental qualities for the proper operation of the vehicle. The repair personnel had to be trained along new lines in the repair and upkeep of the vehicles if operation was to be economical and safe. The author then outlines and comments upon the valuable training course available at the Carnegie Institute of Technology.

FOUR YEARS ago, in answer to many inquiries for men trained for management specifically applying to the economics of the motor-vehicle and its operation, the department of works management of the Carnegie Institute of Technology started a four-year course as an option leading to the degree of Bachelor of Science. This course is, we believe, unique among college curricula, as it offers training in the problems of motor-vehicle transportation. The planning of such a course, emphasizing the major subject of instruction and retaining the broad basic training of a college-engineering education, was a difficult problem. Views of the automotive laboratories, and of the laboratory testing and servicing equipment are shown in Figs. 1, 2 and 3.

Many manufacturers and operators of motor-vehicles were requested to advise what, in their opinion, was required in a course of motor-vehicle management. The replies were generally of great value in the planning, but some of them indicated the opinion that the course could not be made worth while as there was no field for college-trained men in the servicing of private cars or in the fields of commercial operation. However, the constructive replies indicated that such a course should cover the basic requirements of any form of transportation, and specifically motor-vehicle transportation, these basic requirements being stated as safety, dependability, economy, comfort, and speed.

Any executive must possess knowledge of his subject, business judgment and ability. To develop these principles in the training of motor-vehicle executives, we have as a foundation:

(1) *Knowledge.* — Including automobile engineering and the economics of general business and transportation; as well as personnel control and accounting

(2) *Business Judgment.*—In insurance and in legal matters

(3) *Executive Ability.*—In the operation of vehicles, maintenance and statistical control

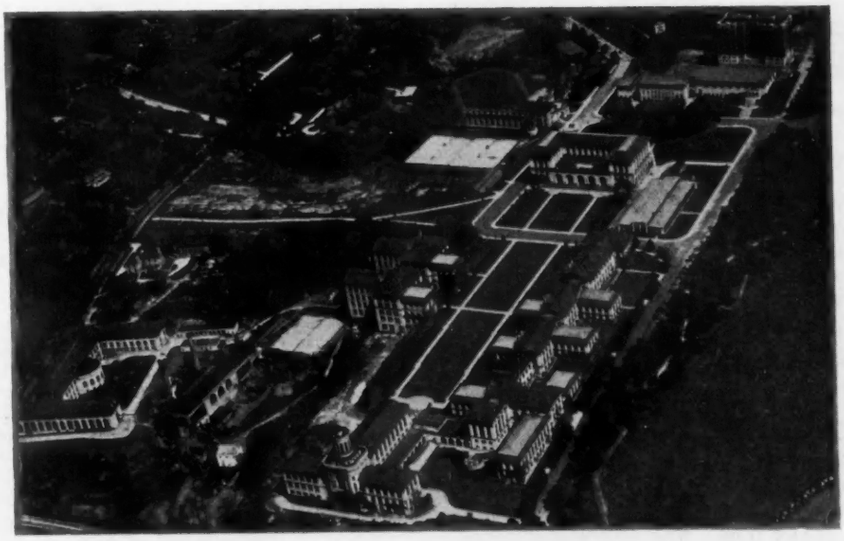


FIG. 1—GENERAL VIEW OF AUTOMOTIVE LABORATORIES AT THE CARNEGIE INSTITUTE OF TECHNOLOGY

Outline of Four-Year Course

An outline of the full four-year course as offered by the College of Industries at Carnegie Institute of Technology and leading to the degree of Bachelor of Science in Works Management, or the Automobile-Service-Management option, is as follows:

[1] M.S.A.E. — Professor of automotive engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

	No. of Units[2]
Freshman Year; First and Second Semesters	
Mathematics	9
English	9
Industrial History	9
Hygiene	2
Physical Education	2
Shops; including masonry, foundry, pattern, welding, machine, forge work	6
General Chemistry	9
Reserve Officers Training Corps (Elective)	5
Sophomore Year; First Semester	
Mathematics	9
Economics	9
Physical Training	3
Physics	12
Specifications and Letters	6
Chemistry of Materials	9
Machine Practice	3
Forge Practice	3
Typewriting	3
R.O.T.C. (Elective)	7½
Sophomore Year; Second Semester	
Mathematics	9
Economics	9
Physical Education	3
Mechanics	9
Physics	12
Chemistry of Materials	8
Foundry Practice	3
Pattern Practice	3
R.O.T.C. (Elective)	7½
Summer Session; Two Weeks	
Surveying	6
Junior Year; First Semester	
Psychology	9
Personnel Management	9
Mechanics	9
Powerplants	9
Production Estimating	6
Mechanism	6
Accounting	6
R.O.T.C. (Elective)	6
Junior Year; Second Semester	
English Literature	9
Mechanics	9
Materials	6
Powerplants	9
Production Methods	6
Factory Cost-Systems	6
Automotive-Engineering Theory	9
R.O.T.C. (Elective)	6
Senior Year; First Semester	
Banking and Credit	9
Industrial Management	9
Electrical Engineering	9
Machine Design	9
Production Management	9
Automotive-Service Management	9
R.O.T.C. (Elective)	6
Senior Year; Second Semester	
Commercial Law	9
Financial Organization and Management	9
Electrical Engineering	9
Automotive-Engineering Design	6
Automotive-Service Practice	12
Automotive Electricity and Carbureters	9
R.O.T.C. (Elective)	6

[2] The value of a unit is based upon the work for a week for a semester, counting three units for a recitation or a lecture, two units for a home study or preparatory hour, and one unit for a laboratory hour.

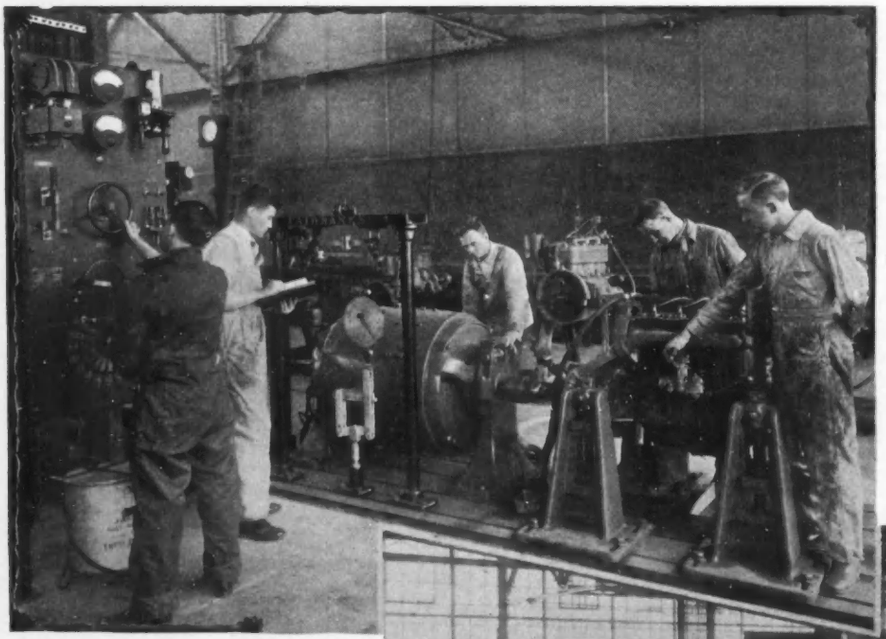


FIG. 2—AUTOMOTIVE LABORATORY-EQUIPMENT AT THE CARNEGIE INSTITUTE

The subjects of instruction offered in the freshman year are common to all regular day-courses offered in the College of Engineering and the College of Industries. They consist of academic and technical studies as well as certain selected shop-courses. The purpose is to enable the student to grasp the fundamental subjects before entering upon a more specialized program. The freshman is expected to elect his major option before completing the school year in either of the colleges mentioned.

In the department of works management, the sophomore-year instruction is a combination of engineering, industrial and liberal-arts subjects planned so as to furnish a sound preparation for the management field in the manufacturing or operating industries. The aim is to give a thorough grounding in the fundamental principles of management. The junior year offers a

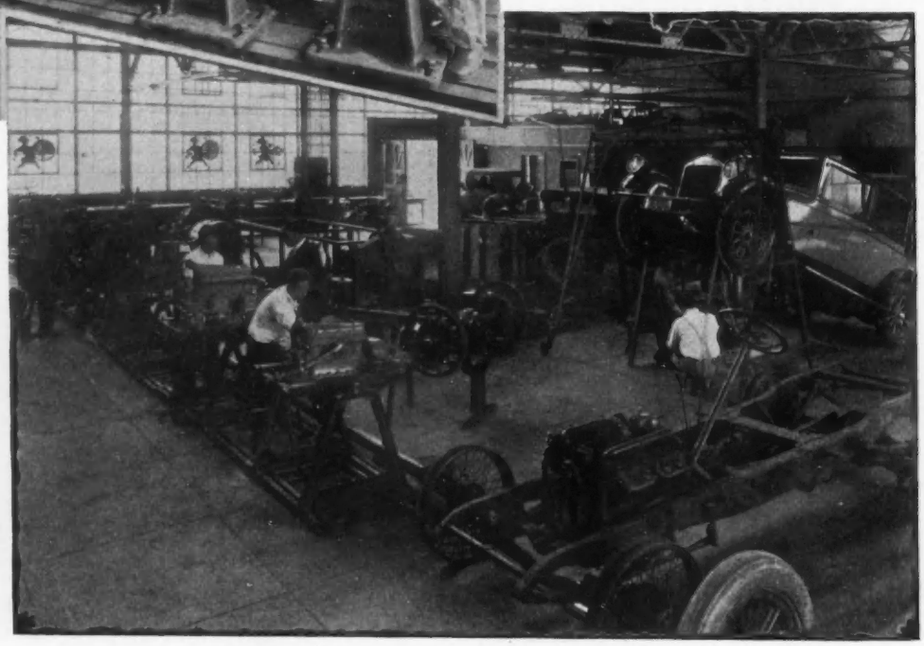


FIG. 3—AUTOMOTIVE SERVICING AT THE CARNEGIE INSTITUTE

continuation of the subject matter of the sophomore year. The junior elects before the end of the first semester the division of his major option to be either works management or automotive-service management. Beginning with the second semester of the junior year, a well-defined start is made upon the division of the selected option. The senior year carries the curriculum to completion, rounding out the course by instructional emphasis upon the subjects of the elected major-option.

Fleet Superintendent Needs Basic Training

The executive of a motor-vehicle operation, regardless of the size or field of the operation and of his position or the extent of his authority, must have a sound basic-training in the fundamentals already outlined. The training offered can be regrouped from the subjects of instruction as tabulated herewith.

The foregoing subjects are those having direct bearing upon motor-vehicle operation. The complete curriculum is a training in management for the student who desires to enter the automotive field in the construction, operation or maintenance branches.

Breadth of Course Offered

The course as planned is a broad one. It would be possible to narrow it and make it somewhat like a trades' training or a course concentrated on motor-vehicle economics alone; but for the student who desires such instruction there are the short, one-year courses of instruction along trade lines, such as the Automobile Maintenance and Aviation Mechanics' courses given both day and evening.

The basic principles are taught in all the subjects, including the laboratory and shop. The instruction represents an effort to teach the broad rule and not the specific method, so that, when the student completes the curriculum, he can begin his work in the commercial field with an open mind.

Knowledge.—

(1)
- Automobile Engineering
- Automotive-Engineering Theory
- Machine Design
- Automotive-Engineering Design

(2) Economics of

(*a*)
- General Business
- Economics
- Banking and Credit
- Financial Organization and Management

(*b*) Automotive Service Management

(3)
- Personnel Control
- Personnel Management

(4)
- Accounting
- Factory Cost-Systems

Business Judgment.—

(1)
- Insurance and Legal Matters
- Commercial Law
- Specifications and Letters

Executive Ability.—

(1)
- Operation of Vehicles
- Automotive-Service Practice
- Automotive Electricity and Carbureters

(2)
- Maintenance
- Automotive-Service Practice
- Freshman Shops
- Sophomore Shops

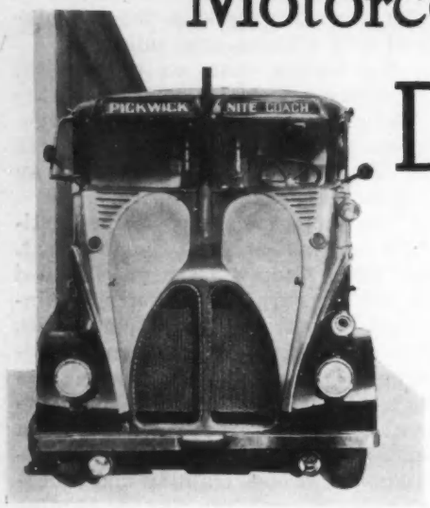
(3)
- Statistical Control
- Production Estimating
- Factory Cost-Systems

We believe that, on the subject of motor-vehicle transportation, the course in automotive-service management as given at Carnegie Institute of Technology is as complete as an engineering school can give.

The scope and aims of the Institute are indicated by the fact that, in 1900, Andrew Carnegie founded it for the purpose of offering training in the trades and opportunities for education to young men handicapped by insufficient funds and the lack of earlier schooling. The several courses offered would be taken either during the day or in the evening. The trades' training and educational branches were planned to meet the requirements and demands of the local industries for trained men. These demands quickly broadened to include men trained not only along trade lines but men trained along technical lines relating to the trades and industries. Since the founding, the scope and aims have broadened greatly and the curriculum has grown to a point undreamed of by its founder. The growth has made it necessary to divide the Institute into four colleges: the Margaret Morrison Carnegie College, the College of Fine Arts, the College of Engineering, and the College of Industries.

The College of Industries has retained the initial trades courses and has added the new courses leading to the degree of Bachelor of Science in Building Construction, in Printing, in Industrial Education, and in Works Management. The last gives the option of a four-year course in Automotive Service Management, a one-year Automobile Maintenance and Operation course and a one-year Aviation, Plane and Engine Mechanics course. The two last courses are also given at night.

Motorcoaches Designed *and* Built *by an* Operator



Toronto Transportation Meeting Paper

By DWIGHT E. AUSTIN[1]

SEVERAL outstanding requirements, the meeting of which has been proved by experience to be very desirable, exist for motorcoaches that are to be used on journeys of more than 2 or 3-hr. duration. First in importance is comfort of the passengers, which involves seat design and spacing. Reclining seats, having deep cushions, should be used, and they should be simple in construction, light, amply strong, and the parts should be accessible for the making of repairs. Comfortable heating should receive careful attention, and the construction should make the entrance of exhaust gases into the coach body impossible; therefore, it is necessary to make the floor proof against the entrance of gas and dust. Lights should be of sufficient candlepower and placed so as to make reading in the coach easily possible.

Choice of the method of providing baggage space varies somewhat in different localities and with the design of vehicle; however, it is highly desirable that all baggage be carried inside the coach and under the owners' vision and supervision.

The chassis and the body should be built into a single mechanical unit, thus saving weight and increasing the structural strength of the motorcoach as a whole.

Better braking-systems, with larger frictional areas and better air-circulation to reduce frictional heat, are needed. To that end the Pickwick Motor Coach Works is experimenting with a double brake-drum having an air chamber cast integral with it.

Engines of at least 150 hp. should be used in the large motorcoaches, and other parts should be made strong in proportion. All chassis and mechanical parts should be made lighter and stronger than at present by the use of suitable alloys, and spring suspension should be improved.

I can set out in a more concrete way some of my ideas by explaining a few of the features of the Pickwick Nite Coach and Duplex Coaches shown in Figs. 1 and 2, which I designed with the thought of comfort, long life, low maintenance-cost and accessibility foremost in my mind. To this end, the entire powerplant, including engine, transmission, clutch, gearshift, control levers, foot throttle, gages, instrument board and fuel system, has been assembled so that it can be removed and another such unit substituted by two men and the coach be ready for the road in 15 min. The front or rear axle, including the springs, can be changed in the same time. The springs are of a special duplex design having double main leaves and shackle pins to double the safety factor at these points. These springs are made on the two-stage principle and are exceptionally easy riding. The driveshaft assembly can be replaced in 10 min. when the engine is out of the chassis, and all other parts are equally accessible.

Similar accessibility is provided in the body design. The seats can be removed in a few seconds, and the upholstery covering or pads can be replaced almost

Seat design, back-to-back spacing and comfort factors are foremost among the outstanding requirements for motorcoaches used on journeys of more than 2 or 3-hr. duration, in the author's opinion. Reclining seats having deep cushions should be used. Their design should be simple, and they should be of light weight, accessible for repairs and as strong as possible.

Heating and lighting equipment should receive adequate consideration, the author says, as well as baggage storage. Features of the Nite Coach and the Duplex Coach built by his company are then described, and further details are given in the discussion which follows the paper.

[1] Vice-president and chief engineer, Pickwick Nite Coach Corp., Ltd., Los Angeles, and vice-president and general manager of the Pickwick Motor Coach Works, Ltd., Los Angeles.

instantly. All other trimmings, such as window curtains and so on, can be easily replaced. All windows and glass are installed from the outside and can be replaced without entering the body, saving much of the labor usually required when working on the inside. Body and chassis are built as one unit and entirely of metal. The main body-sheets are well fastened and form the inside body-panels. They need not be removed when making repairs to the outside of the body. The outside panels are the last installed and are the easiest to replace if damaged.

A new principle has been employed in building these coaches. Instead of the usual practice of building the outside shell and then working under difficulties to finish the interior, we build all the inside sections and install seat brackets and other parts first and then put the outside around them. The exterior panels, windows and other outside parts are the last to be installed and the easiest to be repaired in the event of damage.

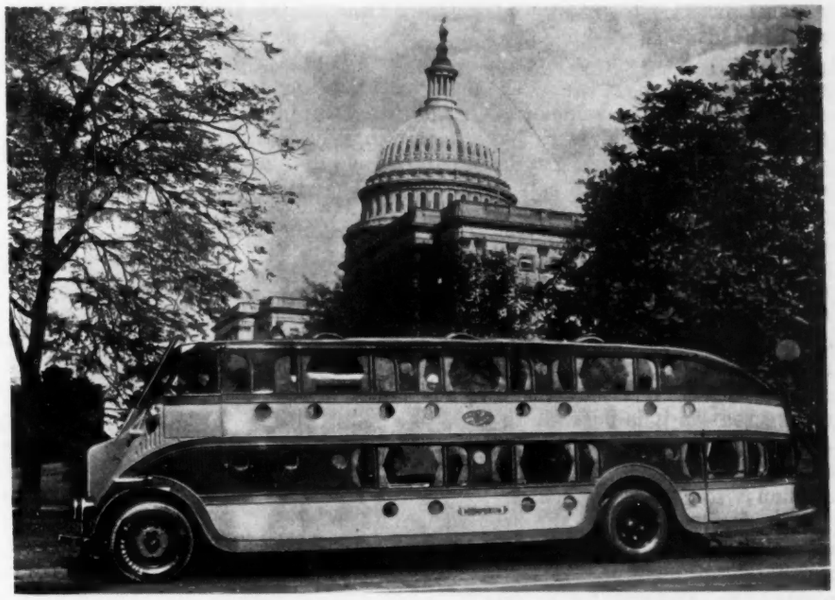


FIG. 1—PICKWICK NITE COACH. THE UNITED STATES CAPITOL AT WASHINGTON IS SHOWN IN THE BACKGROUND

There are many other details that I will not mention, but I believe that most of the features mentioned are absolutely necessary for the most successful motorcoach operation in the future. One other statement I might make is that any seating arrangement that can be worked out to increase the seating capacity without sacrificing passenger comfort or enlarging the over-all dimensions of the vehicle will be welcomed.

THE DISCUSSION

C. G. MOORE[2]:—Concerning our company's system for rating drivers, the ratings are Class *B*, Class *A*, Class *AA* and Class *AAA*. A new man is rated in Class *B* when he begins work and is advanced to the higher classes as quickly as he is able to prove his capability to his superiors. He is not allowed to progress beyond Class *AAA* until after a certain period of time and after having established a clean record for avoidance of accidents. The wages paid differ for the four classes. We believe that from the practical viewpoint the best results are obtained by paying a man more when he shows himself capable of doing better work. Comparing Class-*B* and Class-*AAA* drivers, the former are paid a certain wage for driving over a certain route but a Class-*AAA* driver over the same route is paid a much higher rate. But we have found from actual records that the Class-*AAA* driver is the least costly to the company.

If a Class-*AAA* driver has an accident which we believe was avoidable, he may be demoted and his pay would be reduced accordingly. This brings forcefully to his attention the fact that he must improve his work. We have found this system very effective in the elimination of accidents. In operating between San Francisco and Los Angeles, the vehicles travel 460 miles in 14½ hr. and we have had no casualty for more than 3½ years. We believe our drivers avoid accidents.

To be able to make a reasonable scheduled speed without making passengers nervous, our experience with the Nite Coach shows that the best way to cure nervousness is to prevent the passenger from seeing the road ahead just as passengers on a Pullman car are prevented from seeing the track ahead of the locomotive. The main reason that this prevents nervousness is that the passenger is not mentally attempting to do the driving. Since he cannot see the road ahead, he is not mentally dodging any obstacle or wondering if the vehicle will hit some other vehicle or go into some hole in the road. He merely sits in his seat, relaxes and enjoys his ride. I have no hesitation in saying that, before long, it will be

[2] Eastern representative, at Chicago, of the Pickwick Nite Coach Corp., Ltd., and the Pickwick Motor Coach Works, Ltd., Los Angeles.

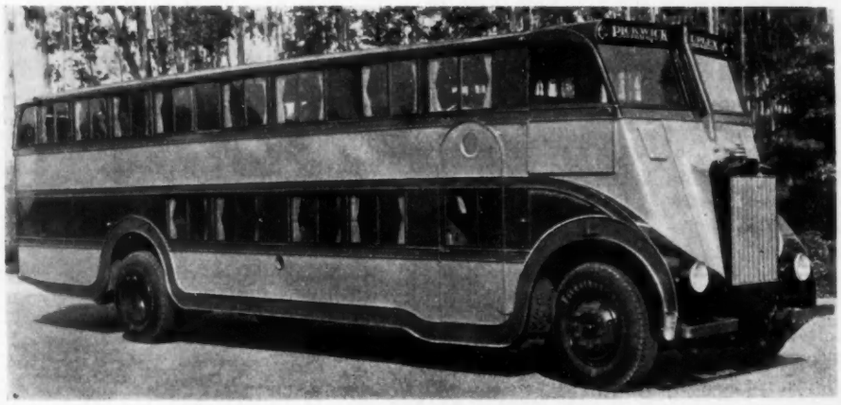


FIG. 2—A VIEW OF THE PICKWICK DUPLEX COACH

general practice to prevent passengers from seeing the road ahead of the vehicle.

A question was asked recently whether 6 m.p.h. per sec. per sec. was feasible as the maximum possible deceleration of a motor-vehicle. Our company's opinion is that, provided the drivers have been properly trained, a motor-vehicle should be designed for maximum deceleration so that it can be stopped within the minimum distance just as the trains on a railroad are stopped in an emergency. Locomotive engineers are trained to make an emergency stop when necessary, yet they do not make use of this maximum capacity every time they reach a railroad-station stop. We believe that discretion should lie with the operator of the vehicle and that his available mechanical power to stop the vehicle should be as great as it is possible to make it.

H. V. MIDDLEWORTH[3]:—Is length of service of the drivers considered in connection with the classification?

MR. MOORE:—One of the requirements in addition to his record is that a Class-*AAA* driver must have been in the employ of the company for a certain length of time.

QUESTION:—On the San Francisco-Los Angeles run, how long does a driver operate?

MR. MOORE:—One man drives 6½ hr.; the other 8 hr.

QUESTION:—Are these drivers given a physical test or an interview as to the amount of sleep they have had before they start on the night ride?

MR. MOORE:—Not as yet, although we are considering giving the drivers a reaction test to determine whether the men are in fit condition when they start. This might require say 2 min. before a driver starts, but the plan has not been perfected.

A. W. SCARRATT[4]:—During a long trip, the degree of comfort and pleasure that a passenger derives from his ride is directly related to the personal freedom provided. My reaction to the two types of motorcoach described is that each passenger's available space is distinctly limited and that a person might not want to ride in such a constricted space especially in cases where the maximum number of people are occupying the vehicle. Another factor which must be considered when transporting so many people in an enclosed vehicle is related to the personal cleanliness of each individual. This determines to an extent how closely they can be packed together with a reasonable degree of passenger comfort. The seating arrangement of the Duplex Coach described seemed to me to form a basis for many objections. I refer to the long-distance 50-passenger parlor-car type.

MR. MOORE:—The Duplex Coach has the maximum cubical space because the lower floor is dropped below the propeller-shaft and the height of the coach is somewhat greater than that of the other type of vehicle. All this cubical space is utilized and there is more space for each passenger than in any other type of coach that we have developed. The seats in the parlor-car are about 39 in. wide; it compares favorably with that of any other intercity parlor-car of which I know, and the leg room is greater than that for any conventional type of coach. The Duplex Coach probably has as much baggage-carrying capacity as the parlor-car, which has interior baggage racks over the seats.

Regarding personal cleanliness and close contact of the passengers, we experienced this in cases of migration of the Mexican working class from Mexico into California and return. To avoid the condition mentioned, on runs where we have found this to be necessary, we have established parlor-buffet extra-fare schedules so that, by paying about $1.50 extra between Los Angeles and San Francisco, a passenger has access to the better equipment and can associate with a class of people similar to that which rides in Pullman cars on the railroads. We found this unprofitable when the plan was first put into operation, but now the extra-fare trips during the day are the most profitable.

C. G. MOORE

To provide adequate ventilation for 50 passengers, the coach is equipped with a power take-off in the transmission which drives a large fan. This forces the air which it takes in on the front portion of the roof through pipes which connect with each one of the compartments. Hence, forced-draft ventilation is provided for each compartment of the Nite Coach and also for the Duplex Coach. A test was made by three men who smoked cigars in one of these compartments in an attempt to fill it with smoke. This they were able to do so long as they puffed like miniature steam engines but, as soon as they smoked only ordinarily hard, the smoke immediately cleared out.

Disposition of Passengers' Baggage

G. O. POOLEY[5]:—My experience indicates that people are often deterred from riding in motorcoaches because of the bad treatment given to their baggage. The statement is made in the paper that baggage should be under the supervision of the owner and visible to him. Does that mean that it should be disposed in racks over the seats and inside the coach?

MR. MOORE:—On our Nite Coach and the Duplex Coach some spaces are utilized for baggage that ordinarily would be simply dead space. When the passenger is in a compartment his traveling bag is there also. A larger space is provided in the rear of the coach, inside the body shell, where an overflow of baggage can be accommodated.

CHAIRMAN A. S. MCARTHUR[6]:—The storage of baggage on motorcoaches undoubtedly has been one of the major problems, from the operator's viewpoint, that the manufacturers have had.

The prevention of forward vision of the passengers is an important feature. What are the advantages and disadvantages of a bulkhead behind the driver?

Advantages of Forward Bulkhead

MR. MOORE:—The most important advantage is, in addition to preventing the passengers from becoming nervous, that a bulkhead enables a driver to exclude all light from the interior of the coach and thus elimi-

[3] M.S.A.E.—Superintendent of operations, transportation department, Consolidated Gas Co. of New York, New York City.

[4] M.S.A.E.—Chief engineer, motor-trucks and coaches, International Harvester Co., Chicago.

[5] M.S.A.E.—General buildings and supplies superintendent, Chesapeake & Potomac Telephone Co., Baltimore, Md.

[6] M.S.A.E.—General superintendent, Toronto Transportation Commission, Toronto, Ontario, Canada.

nate from his compartment any usual reflections that ordinarily are cast from the windshield. Another advantage is that in long-distance operation, particularly at night, the driver can ventilate his compartment independently of the ventilation provided inside the coach. When the interior of the coach has a temperature at which passengers can sleep in comfort, the air is too warm and the driver is not so alert. He becomes drowsy and this drowsiness is aggravated while listening to the hum of the engine. But when he is in the driver's compartment, he can open the ventilators and windows and regulate the temperature so that no tendency toward drowsiness exists and he continues to be alert.

A bulkhead also prevents interference from passengers. Without it, people often are thoughtless enough to speak to the driver just as he is about to pass another vehicle or meet some other emergency. Rather than to appear to be discourteous, the driver would very likely attempt to answer and disastrous results might follow.

A. D. FERGUSON[7]:—Is the amount of baggage a passenger may carry limited?

MR. MOORE:—We have not yet found it necessary to limit personal baggage. Room enough is provided to accommodate two pieces of baggage for each passenger and that has proved sufficient.

Reactions of the Public

MR. SCARRATT:—What is the general reaction of the public—both men and women—to the Nite Coach, considering the rather limited space and especially referring to sleeping space?

MR. MOORE:—The general impression the public has is that the passengers must be cramped for room; but, in fact, the berths are 2 in. longer than the conventional Pullman berth and they are 25 in. wide. A Pullman berth is about 39 in. wide. Hence, the berth is about two-thirds as wide as the Pullman berth and is 2 in. longer. In place of the usual upholstery, the seats are covered with a rubber pneumatic mattress which insulates passengers from shock. The mattress forms the seat uphostery during the day and spreads out to become the mattress and spring of the berth at night. The mattress cushions a shock and does not have the rebounding power of a spring; therefore, the mattress, acting as an air cushion, allows the passenger to sleep comfortably. Women seem more pleased with it than do the men. The compartments afford almost complete privacy and, when seated in a compartment, one is only able to see the passengers who are sitting in the compartment exactly opposite. The percentage of passengers carried increased rapidly during the first four months of operation.

A. W. SCARRATT

Scheduled Rates

A. A. LYMAN[8]:—What are the respective fares between Los Angeles and San Francisco, comparing travel in the Nite Coach, the railroad day-coach and the Pullman car?

MR. MOORE:—The excess fare on the Nite Coach is approximately 1 cent per mile for approximately the first 300 miles. We charge $3 additional for the sleeping accommodation between those two points, but the minimum is perhaps $2 and the maximum $3. The rate varies in proportion to the miles traveled; that is, in addition to the regular motorcoach fare charged for a given route. The vehicles are leased to the operators on a plan somewhat similar to that followed by the Pullman company. They are maintained by the Nite-Coach company; but the driver, gasoline and oil supplies and the route on which they run are controlled by the company which operates the vehicle.

F. C. HORNER[9]:—What is the motorcoach fare between Los Angeles and San Francisco?

MR. MOORE:—The fare is $11, and the berth is $3.

MR. HORNER:—What is the railroad fare?

MR. MOORE:—It is $17, and the Pullman fare is $4.50, a total of $21.50.

N. G. SHIDLE[10]:—What percentage of the patrons engage an entire compartment?

MR. MOORE:—The percentage is no greater than is usual on a Pullman train. The regulation motorcoach fare is a fare and one-half; for the Nite Coach it is two fares less 10 per cent. This plan is similar to railroad practice in renting compartments.

Road Repairs Described

A. M. WOLF[11]:—In my experience, when a unit or units are disposed so as to be quickly replaceable, the parts are likely to be inaccessible if attention is needed along the roadside, such as repairs to the carbureter and magneto. Do the drivers have access to the vital powerplant parts?

MR. MOORE:—The carbureter and the magneto are made accessible after lifting the floor-boards. It is true that they are not as accessible as when the hood is lifted, but no crane is needed to remove the power unit from the chassis frame. In case of serious engine trouble, the tracks which are carried underneath the vehicle are placed in front in an inclined position and the engine, controlled by a winch, is allowed to slide down these tracks on wheels permanently attached to the power unit. In this manner it is possible to take the engine out of the chassis wherever a level space on the road can be found. It is pulled back into place in the chassis by a built-in winch. The drivers are capable of doing this very quickly. Further, it is also possible to set the engine out at a suitable distance from the vehicle and operate it through a cable connected with the batteries.

MR. WOLF:—Will Mr. Moore explain the double brake-drum that has been referred to?

MR. MOORE:—The drum is cast in a manner similar to the practice for producing the conventional type of drum, but the interior and the exterior braking-areas are separated by an air chamber. It is strengthened

(*Concluded on p. 559*)

[7] Assistant engineer, Canadian National Railway, Montreal, Canada.

[8] M.S.A.E.—Automotive engineer, Public Service Coordinatetd Transport, Newark, N. J.

[9] M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

[10] M.S.A.E.—Directing editor, Chilton-Class Journal Co., Philadelphia.

[11] M.S.A.E.—Automotive consulting engineer, Newark, N. J.

New Developments *in* Machining Aluminum *and* Its Alloys

Production
Meeting Paper

By R. L. Templin[1]

COMPARATIVELY large rake and clearance angles required for best results leave a relatively thin cutting-edge on a cutting tool for aluminum. One difficulty encountered is that tools of such form are not always available or suitable, for various reasons; for instance, small tools of various types are available only with cutting edges suitable for steel and bronze, and the desirable amount of top rake cannot well be provided on circular form-tools.

Tool bits of various sorts can be reground to the desired angle. A simple round form of tip that is shown can be utilized in tools for various purposes, including use as inserted teeth in a face-milling cutter. High-speed-steel tools are suitable for most aluminum alloys, but alloys containing a high percentage of silicon can be machined to advantage only by using cemented tungsten-carbide.

Machine-tools should be suitable for high speed. Rigidity is required and lost motion must be prevented to guard against a tendency for the thin points of the tools to dig into the work.

Some experienced machinists find it hard to mentally adapt themselves to the tool form and speeds that are suitable for working aluminum.

A bibliography containing references to a number of articles on the subject that have appeared in American and foreign trade papers, books and house organs, is appended.

MUCH INFORMATION has already been published on the general subject of machining aluminum. Reference to much of this is given in the appended bibliography. The many improvements, however, that are constantly being made both in machine-tools and in the alloys of aluminum present new problems the solutions of which bring out many facts heretofore unemphasized or unrecognized. Introduction of new materials such as cemented tungsten-carbide for cutting tools has stimulated research work in machining aluminum, as in the machining of other metals, with results which modify previously established machining practice.

At the risk of some repetition, it seems advisable to point out, first, the essential shape-requirements of a cutting tool best suited for use in machining aluminum and its alloys. As the result of considerable experimental work, substantiated by data from the production fields, it appears that such a tool should have a top rake of about 45 deg. and a front or back clearance of about 7 deg., making the total included angle of the cutting edge approximately 38 deg. The side rake should be about 15 deg. In addition, it should be emphasized that the edges of the tool must be keen; that is, smooth and free from wire-edges or burrs.

When used under suitable conditions, a tool of this form will produce (*a*) a clean-cut smooth surface on the work; (*b*) the minimum disturbance of both the surface of the work and the metal being removed; (*c*) the minimum of frictional heat; and (*d*) little if any deposition of metal on the top of the cutting edge of the tool. In view of these facts, a tool of this form may be considered as best suited for cutting aluminum and its alloys. It must be recognized, however, that such a tool may not always produce the greatest amount of finished work with the least attention, in shortest time and at the lowest cost; that is, it may not be the most efficient tool to use under every given set of operating conditions. This will be understood better from what follows.

Tool Form Cannot Always Be Ideal

Unfortunately for the machinist, many other factors must be given due consideration simultaneously with tool shape if the best results are to be expected in the machining of aluminum, as of other metals. The more important of these factors include

(1) Type of tool
(2) Tool material
(3) Rate of cutting, or amount of stock removed per unit of time
(4) Coolant
(5) Character of the work
(6) Machine-tool used
(7) The operator's personal equation
(8) Availability of commercial tools and machines of the desired kind.

The type of tool frequently imposes limitations that materially decrease the production rate because the desired shape-requirements cannot be met. Such limitations are sometimes found in circular forming-tools, in which a marked difference in diameter at different parts of the contour makes it quite impracticable to provide the desired cutting-edge angles. Again, the

[1] Chief engineer of tests, Aluminum Co. of America, New Kensington, Pa.

cutting edges of the tool may be of the desired shape but the design of the tool may not allow ample provision for disposing of the continuous and but slightly curled cuttings that are characteristic of many of the alloys of aluminum. This applies to automatic dieheads of certain types that are available in the market.

The material from which the tool is made will affect not only the life of the tool but also its cutting rate. The choice of tool material, be it high-carbon or high-speed steel or cemented tungsten-carbide, will be governed to some extent by the type of tool, the machine with which the work is to be done and the character of the work. High-carbon-steel tools, ground to the thin cutting edges desired for aluminum, may fail early because of brittleness. High-speed-steel tools give much better results when machining alloys of aluminum except those containing appreciable amounts of silicon. These high-silicon alloys, however, can be readily machined on a production basis by using cemented-tungsten-carbide tools. Apparently there are differences in the bonding material or degree of bonding between the various kinds of the cemented-tungsten-carbide tools; sometimes even between different lots of the same make. Those kinds and lots which have the greatest toughness seem to give best results in machining aluminum.

Correct Tool Shape Speeds Cutting

The rate of cutting is a function of speed, feed and depth of cut. All of these may be and usually are closely related to one another and also to any or all of the other factors under consideration. If, for example, the tool is of the desired shape, very high speeds frequently can be used in machining aluminum. However, because of the comparatively thin cutting-edges of the tools, rather fine feeds with moderate depth of cut, or moderate feeds with small depth of cut, will generally give the best results. When the type of tool is such that the desired shape of the cutting edges cannot be used—for example, the optimum top rake—a marked curling of the cuttings or chips may occur, with consequent increase in the frictional heat developed. Such conditions require a lower cutting-speed, smaller feed or depth of cut, or more coolant.

The coolant used in cutting metals serves to carry off the heat generated during the machining operation, and it may to some extent and probably does act as a lubricant both between the chip and the tool and between the work and the tool. The comparatively high thermal-conductivity of aluminum materially assists the coolant in performing the first of these functions, while the nature of the coolant is of more importance in the other. Experience to date has indicated that a mixture of lard-oil and coal-oil or kerosene, usually of equal parts, generally will give satisfactory results as a coolant. The proportions indicated can often be varied to advantage, according to the character of the work being done. More lard-oil is used for heavy cuts and more kerosene may be used for light cuts at high speed. It must be pointed out, however, that satisfactory results are frequently obtained from the use of solutions of soluble oil and water.

The form of the work and the sort of finish required will affect the results obtained, according to whether the part must have a high degree of finish; must have accurate or approximate dimensions; and requires this or that type of tool, indicating machining with lathe, shaper, milling-machine, drill-press or other machine-tool. This fact may be obvious to many, but experience has shown that some of these items are frequently ignored in selecting speeds and feeds for a given job. If the work must meet close dimensional tolerances, appreciable temperature rise must be prevented, usually by resorting to lower speeds or less feed than could otherwise be used.

Machine-Tools and Operators Need Readjustment

Some machine-tools used in machining aluminum are of such design or in such mechanical condition as to preclude the obtaining of satisfactory results. Worn spindle-bearings; lost motion in lead-screws or feed mechanism; and too much spring in tool-posts, arbors or holders, permitting chatter or "hogging in" of the cutting tools, all directly preclude satisfactory results when machining aluminum. Until somewhat recently, few machine-tools were available that were designed to give the high cutting-speeds recommended in machining aluminum. The advent of the cemented-tungsten-carbide tools has assisted much in diminishing this difficulty. Still some modern machine-tools do not provide speeds as high as could be used advantageously in machining aluminum.

A machine-tool operator whose experience, though considerable, has been confined almost entirely to the machining of brass and steel is frequently quite reluctant to use tools having the extreme shape recommended for aluminum. The more extensive his experience has been, generally, the greater is his inertia toward using new ideas. Not infrequently difficulties in machining aluminum in a production shop have been traced to this cause. It is necessary both that the operators understand what the correct tool shapes are and that they use them when machining aluminum.

Most of the standard types of machine-tools available in the commercial field until recently were designed primarily to meet the requirements for free-cutting brass or steel. Introduction of the cemented-tungsten-carbide tools has shown the need for higher cutting-rates. Accordingly we find, incorporated in some of the newer machine-tools, provision for much higher spindle-speeds and feeds, better bearings, and other features that go with the increased cutting-speeds. In general, these features are all favorable to the better machining of aluminum.

Making Correct Tools Available

The machinist is frequently obliged to use commercial types of small tools primarily intended for brass or steel when machining aluminum. That is, if the desired type of tool is not available in the toolroom, it must be ordered as a special tool. That frequently involves too much delay for the job at hand. Either the delay or the use of a poorly adapted tool is unsatisfactory. It is to be hoped that manufacturers of small tools for cutting metals will point out more clearly in their sales literature the types that are suitable for aluminum. If this were done, an increase in the demand for them might reasonably be expected which eventually would be sufficient to cause not only the manufacturers but also the jobbers to carry such tools in stock regularly.

The many factors entering into the successful machining of aluminum that have been pointed out in the foregoing may seem to make the problem unduly com-

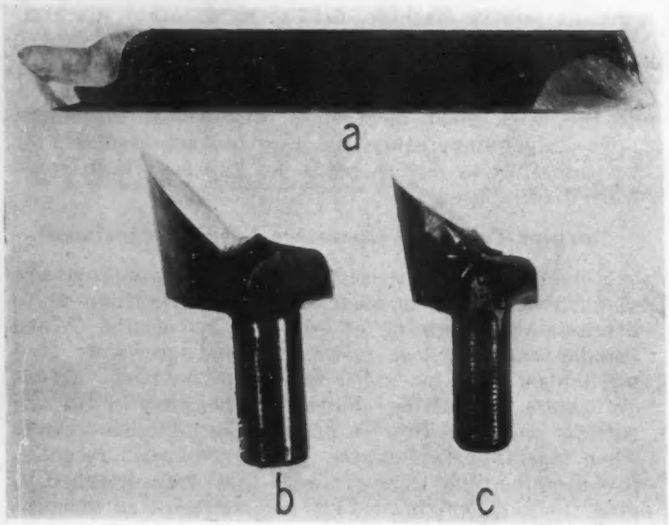


FIG. 1—ORDINARY TOOL-BITS, GROUND FOR ALUMINUM

Bit *a* Is for a Planer or Shaper Tool; *b* Is a Commercial Bit Reground; and *c* Is the Same as *b*, with the Addition of a Tungsten-Carbide Tip

plex, but in reality the same factors obtain in any metal-machining problems. They are reviewed here to emphasize the necessity for giving each factor due consideration when machining new metals or using new tool-materials. Most machinists are too prone to accept some of the factors as constants rather than as possible variables in any given machining problem. It is then in the province of the production engineer to see that the right kinds of machines and tools are available, and it is in the province of the foreman to see that they are properly used.

It is frequently possible to provide tools having the correct shape of cutting edge by merely regrinding available tools of more or less standard shape. The tool bits shown in Fig. 1 are examples of this. Bit *a* is a shaper or planer-tool bit, ground from high-speed-steel stock, while bit *b* is a patented drop-forged high-speed-steel bit that has been made suitable for aluminum by simple grinding. Further improvement is obtained in bit *b* by brazing a piece of cemented tungsten-carbide to it, as shown in bit *c*. The tool bit of the form shown in Figs. 2 and 3 is a general-purpose bit, usually made of high-speed steel, that can be readily adapted to lathe, shaper, or planer tools, boring-tools and even face-milling cutters with marked advantages for machining aluminum. Tool bits of this form are readily made from round stock and easily resharpened and replaced. A considerable range of settings for different amounts of top and side rake can be made by rotating the bit or bits in the holder.

Suitable Inserted-Tooth Tools

A face-milling cutter with inserted teeth ground to the desired shape for machining aluminum is shown in Fig. 4. The teeth have 45-deg. top and side rake. This cutter has been operated on cast duralumin at 350 r.p.m., using a feed of 1½ in. per min. with a cut ⅛ in. deep and 6 in. wide. The coolant used was soluble oil in water. Very satisfactory results were obtained under these conditions, but undoubtedly the results could have been improved upon had higher spindle-speeds been available in the machine and had cemented-tungsten-carbide tool-bits been available.

Recently circular saws having teeth tipped with cemented tungsten-carbide have appeared on the market. The saws are regularly furnished with various degrees of top rake on the teeth, different tooth-spacing, and two or three styles of cutting edge and swage. The saws with the tooth shape meeting the requirements indicated previously in this discussion are recommended by the maker as being suitable for cutting asbestos composition-board, red fiber, cork products, gypsum block, linoleum, plywoods and composition wall-boards. Under the right operating conditions, however, such saws will cut aluminum much better than the customary type of circular saw. Correct operating-conditions include high speeds, up to 12,000 linear ft. per min. or possibly more; comparatively light but positive mechanical feeds; secure clamping of the work; and some coolant, such as soluble oil in water.

Such saws cannot be used successfully in hand or gravity-feed sawing-machines nor under conditions where the work is not firmly clamped in place. Light feeds must be used, to prevent strain on the thin edges of the saw teeth and to produce soft chips that will free themselves readily from both the saw and the kerf. A positive feed must be used so that the hook-shaped teeth will not "hog" into the work and have their tips broken off. High-speed-steel teeth of similar shape and design will give satisfactory results in sawing many of the alloys of aluminum, but the high-silicon alloys require the use of the cemented-tungsten-carbide teeth for best results.

Milling-cutters, reamers and end-mills of the helical type, having considerable top rake on their cutting edges, continue to give good results in machining aluminum. This is also true of spirally fluted taps, but the cutting edges of nearly all such tools could be made thinner to advantage. This usually can be done by grinding an increased amount of top rake on the cutting edges.

In conclusion, it must be emphasized that many properties other than the machining qualities of the material govern the choice of a metal for specific uses. The production of a part from a metal which does not machine readily when using methods and tools ordinarily applied to other materials may well call for new methods and tools. Such methods and tools can come into general use only through the close cooperation of

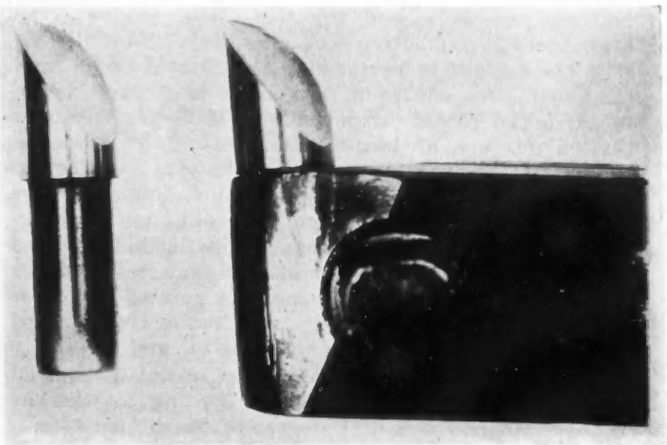


FIG. 2—A ROUND BIT OF SIMPLE FORM

the investigator, the tool manufacturer, the machine manufacturer and the user.

BIBLIOGRAPHY

Die Bearbeitung von Aluminium (The Machining of Aluminum); by P. Vogelsang. *Zeitschrift für Metallkunde*, March, 1927, p. 117.

Machining Aluminum; by R. L. Templin. *The Iron Age*, Sept. 29, 1927, p. 877.

Machining Aluminum; by R. L. Templin. *Proceedings of the Institute of Metals Division*, American Institute of Mining and Metallurgical Engineers, 1928, p. 149.

The Machinability of Metals; by O. W. Boston. *Transactions, American Society for Steel Treating*, January, 1928, p. 49.

Machining Aluminum and Aluminum Alloys; by R. L. Templin. National Metals Handbook, 1930, p. 640.

Report on Machinability; by E. G. Herbert. *The Engineer*, Dec. 21, 1928, p. 692.

The Drill Test as an Index of Workability of Metals; by G. Schlesinger and St. Patkay. *Werkstatts Technik*, December, 1928, p. 676.

Workability, Drillability and the Twist Drill; by St. Patkay. *Werkstatts Technik*, Jan. 1, 1929, p. 1 and Jan. 15, 1929, p. 33.

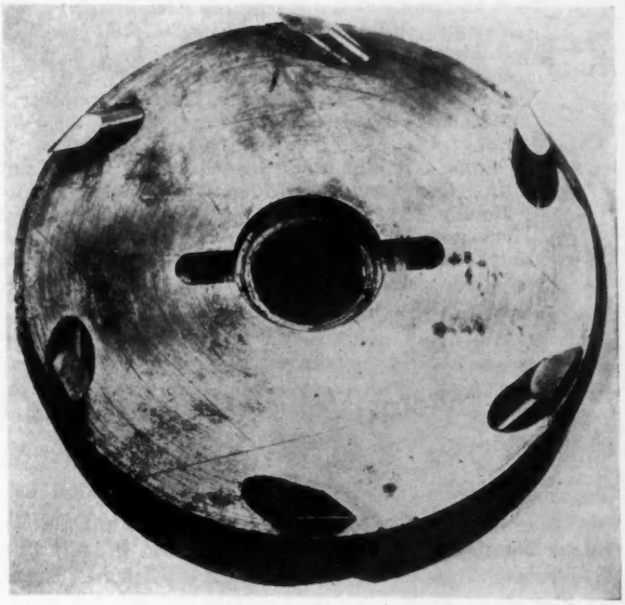


FIG. 4—ANOTHER FORM OF FACE-MILLING CUTTER

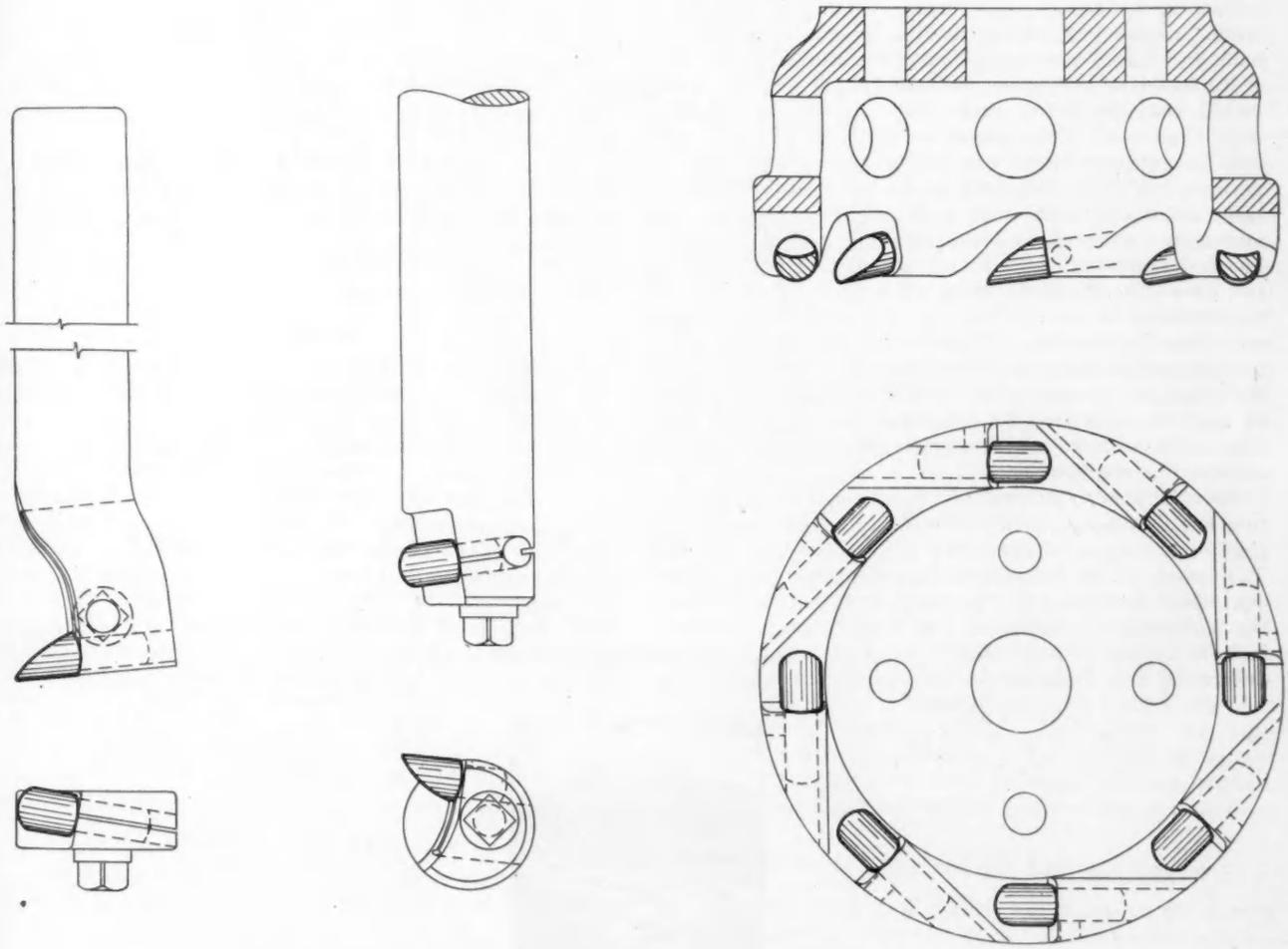


FIG. 3—BIT OF FIG. 2 APPLIED TO TURNING AND BORING TOOLS AND FACE-MILLING CUTTER

Tools and Methods for Machining Aluminum; by R. L. Templin. *Machinery*, March, 1929, p. 557.

Machining Aluminum and Its Alloys; by R. L. Templin. *Aviation Engineering*, April, 1929, p. 11.

Test Methods for Determining the Machinability of Metals; by O. W. Boston. *Transactions, American Society for Steel Treating*, November, 1929, p. 659.

Machining Aluminum and Its Alloys; by R. L. Templin. Houghton's *Black and White*, Metal Edition, January, 1930, p. 18; *The Metal Industry*, February, 1930, p. 67; and *Lefax*, April, 1930, p. 741.

Tungsten-Carbide Tools; by Roger D. Prosser. *Transactions, American Society for Steel Treating*, June, 1930, p. 749.

Le Travail de l'Aluminium et de Ses Allieges (Machining Aluminum and Its Alloys); by A. Dumas. *Revue d'Aluminium*, January, 1930, p. 1042; and February, 1930, p. 1047.

Chapter on Machining Aluminum and Its Alloys, by R. L. Templin, in The Aluminum Industry; by J. D. Edwards, F. C. Frary and Z. Jeffries; Vol. 2, p. 385. McGraw-Hill Book Co., New York City, 1930.

Nose Formed by Tool in Cutting Metal Is Built Up at Any Speed; by O. W. Boston. *Automotive Industries*, June 28, 1930, p. 981. See also *Carboloy*, 1930: March, p. 11; April, p. 22; July, p. 18; August, p. 8; and September, p. 7.

Motor-Vehicle Performance Indicating and Recording Devices

(*Concluded from p. 540*)

be necessary to develop a simple and substantial revolution counter. This should not prove a difficult task. At present, several commercially accurate speed-counters are available. Installation of such a device need not necessarily be complicated and the drive could be taken off the fan, generator, or accessory shaft of the engine.

To register the million or more revolutions that are rolled up by an average engine in a day's operation would require an excessively large counting-index if each individual revolution were registered. This difficulty could be overcome by designing a counter which would register 1 for each 1000 revolutions. Such a unit of measurement might be designated as a "mil-rev," a contraction of the longer term "one thousand revolutions." Development of such an instrument has been discussed both with practical maintenance men and manufacturers, and the idea has met with wholehearted approval. One manufacturer reports interesting developments along these lines and will shortly announce what is said to be a highly accurate and reliable counting mechanism. This particular device, it is understood, is designed for attachment to the ignition distributor. In operation, it will indicate the number of engine revolutions by counting the number of ignition sparks which pass through a magnetically operated registering mechanism.

Several other interesting developments along this line are at present pending, most of which are still in the experimental stage. At the suggestion of *Bus Transportation*, a prominent manufacturer of electrical equipment is redesigning an aviation type of tachometer for motorcoach installation and is perfecting details to include a totalizing revolution counter. The tentative design of this instrument incorporates a method for recording the number of times the engine has been operated in excess of a safe running-speed. At present, full information on both of these instruments is not available; but it is hoped that more complete details can be announced in the near future.

The Ohmer Odometer

Fig. 20 shows an installation on an AB Mack truck of the Ohmer odometer for recording the number of revolutions of the engine, its maximum rating being 1450 r.p.m. In the use of an 8 to 1 Ohmer reduction-gearbox, the odometer registers one (1) count for each 1000 revolutions of the engine, the odometer drive being connected to the oil-pump shaft.

This is the first installation of a recording device for counting the number of revolutions per minute of engines. The installation is practical and accurate in registration. Different models and makes of vehicle require an installation according to the design of the engine for drive take-off.

Summary

In conclusion, during the last 10 years, which covers the development of the modern motorcoach, notably satisfactory technical progress has been made. On these vehicles and particularly on the powerplants and the fundamental units that make up the modern motorcoach, the best available skill in design and construction has been focused. In more recent years attention has been given to the problem of developing suitable mechanisms for recording and indicating vehicular performance. Further progress on equipment of this type must keep pace with the strides that are continually being made in the development of propulsion equipment for the motorcoaches of today and of the future.

Wear and Tolerances on Gages

Production Meeting Paper

By E. J. Bryant[1]

DEFINITE wear tolerances should be set up for all gages in the factory, including master gages, inspection gages, and production gages. A definite time should be set for the inspection of each gage, and a record made of the findings of the inspection. In some factories each gage is numbered and a complete record of the gaging sizes is kept on a card bearing the same number.

Disputes between the inspection department and the production department regarding the sizes of work are of frequent occurrence. They are usually due to gages in the hands of the production department being worn smaller than those used by the inspector. These disputes can be eliminated by proper reinspection of gages and alloting to the production department the larger gage, or the one showing the greater amount of wear, and to the inspection department the gage that is nearer the basic size. This applies to gages of all classes, but particularly to thread-gages in which several elements are subject to wear, including the sides and the minor diameter.

Plug gages wear faster on the front end, and an allowance must be made in setting up the wear limits at which gages must be replaced to take care of this. On an ordinary run of sizes, gages should be rejected that have worn 0.0002 in. undersize ¼ in. from the front end and 0.0001 in. undersize at the back end.

Several factors cause excessive wear of gages, such as small holes or tight work that result in continued forcing of the gage. Dirty work, especially grinding-grit and water in the holes, and even the size of the handle have decided effects upon the life of the gage. The use of dogs or "jitneys" greatly increases the wear of gages.

Definite tolerances for wear, as well as manufacturing tolerances, should be established for gages used in production. Definite periods for checking should also be established for gages in regular service. Care should be taken to check the actual wearing points when inspecting a gage.

Three possible dispositions of the manufacturing tolerance for gages are discussed, the author preferring to split the gage-maker's tolerance on Not Go gages, and on Go gages to apply it to favor the life of the gage.

Alloy steel which can be hardened uniformly is recommended as material for gages. Chromium-plating is criticized because it is not bonded to the base material, and tungsten carbide is recommended for some gages in which the wear is extreme.

Finish of Gaging Surface

The finish of the gaging surface is a very important factor. This is clearly brought out in an article by L. M. McPharlin on The Relation of Finish to Life of Plug Gages.[2] The high, hard finish obtained by mechanical lapping increased the average life of the gages in his tests from approximately 5000 to over 11,000 holes before 0.0001 in. of wear occurred. The general average for ordinary gaging is 1000 gagings per 0.0001 in. of wear on new lapped gages.

A finely ground finish presents a series of comparatively sharp ridges as a gaging surface. We know, from the experience of lapping such a surface until it is clear of grinding marks, that it takes from 0.0001 to 0.0002 in. of lapping before the bottoms of these ridges have been eliminated. From the same experience in lapping we know that this reduction in size can be made in a comparatively short time, whereas it takes much longer to reduce a gage 0.0001 in. after a lapped surface has been obtained. Of course the action of the gage in the work is similar to lapping, but the conditions are different in that the particles in the work that cause wear are of much coarser size, and these coarse grits continually produce deep cuts in the gage surface. If scratches or deep cuts are already present, these grits take hold much more readily. For this reason a ground gage is rarely worn down smooth in production. The microphotographs in Mr. McPharlin's article[2] show clearly the apparently deep scoring of gages in the lapping action while in use.

A shiny surface does not necessarily mean a smooth, flat surface. As a matter of fact, bright, polished surfaces frequently are not sufficiently flat to make good gaging surfaces. Only when the high polish is obtained by flat laps, as in mechanical lapping or the better grade of hand lapping, is a flat surface obtained; that is, a surface in which there are no deep cuts.

Alloy Steel Required for Uniform Gages

Soft spots in gage surfaces are a source of uneven and consequently excessive wear. Special steels are required to consistently obtain surfaces which are uniformly hard. It seems to be more important that the

[1] Affil. Rep. S.A.E.—Manager, gage and reamer department, Greenfield Tap & Die Corp., Greenfield, Mass.

[2] See *American Machinist*, May 12, 1927, p. 775.

gages be uniformly hard than that they be extremely hard. It is usually necessary, however, for a surface to be reasonably hard to prevent accidental bruising or scoring of the surface. Soft steel and thinly case-hardened steel are liable to bruises, which upset the metal and consequently change the gaging size. Gages that have met with accidents of this nature are difficult to repair in a satisfactory manner.

In the case of gaging extremely hard work, it has been found that a hard gage would stand up for only from 25 to 50 gagings, whereas a file-soft gage, carefully used, would gage several hundred pieces before appreciable wear was evident.

The material from which gages are made is important. General practice indicates that crucible alloy-steel with a high carbon-content at the gaging surface makes the most economical and satisfactory gage. The requirement that the gage surface be 100 per cent hard, that is, without soft spots, is most easily obtained through the use of alloy steel.

Chromium plating has been used with varying success. The lack of uniformity in results and the fact that no bond exists between the plate and the metal on which it is applied, making it liable to chip or peel off, have prevented its more general adoption.

Tungsten-carbide gages, although very high in first cost, can be used economically where there is constant production and excessive wear of gages, particularly where close tolerances are to be maintained.

The material being gaged has an important bearing on the life of the gage. Aluminum, brass and cast iron are all much harder on the gages than is soft steel. Some grades of aluminum cause the most excessive wear, particularly if there is any tendency to force the gage. Dry brass parts, especially those containing a high precentage of copper, can be gaged with less gage wear if a small amount of light lubricant is used on the gage.

Great care should be used in cleaning gage blocks. If carefully cleaned so that no fine particles of dirt remain, they can be used a long time without perceptible wear; but under ordinary conditions gage blocks should be frequently inspected, as it has been demonstrated that they are soon worn undersize.

[6] See *American Machinist*, June 12, 1930.

TABLE 1—GAGE-MAKER'S TOLERANCES[3] FOR CYLINDRICAL PLUG-GAGES

Class X—Precision Lapped, for Master and Reference Gages

Size Range	Tolerance
0.060 — 0.825	0.00004
0.826 — 1.510	0.00006
1.511 — 2.510	0.00008
2.511 — 4.510	0.00010

Class Y—Lapped Finish, for Inspection and Working Gages

Size Range	Tolerance
0.060 — 0.825	0.00008
0.826 — 1.510	0.00010
1.511 — 2.510	0.00014
2.511 — 4.510	0.00018

Class Z—Ground Finish, for Wide Manufacturing Limits

Size Range	Tolerance
0.060 — 0.825	0.00010
0.826 — 1.510	0.00012
1.511 — 2.510	0.00018
2.511 — 4.510	0.00025

[3] Tolerances are applied from basic plus for Go and master gages and half the tolerance plus and half minus for Not Go gages.

TABLE 2—TOLERANCES FOR ALL GO AND NOT GO THREAD-GAGES

Threads Per In.	Pitch Diameter, In.[4] Class X from 0 to	Class XX From	Class XX To	Lead, In. ±[5]	Half-Angle of Thread, Min. ±	Major and Minor Diam., In.
80	0.0002	0.0001	0.0003	0.0002	30	0.0003
72	0.0002	0.0001	0.0003	0.0002	30	0.0003
64	0.0002	0.0001	0.0003	0.0002	30	0.0004
56	0.0002	0.0001	0.0003	0.0002	30	0.0004
48	0.0002	0.0001	0.0003	0.0002	30	0.0004
44	0.0002	0.0001	0.0003	0.0002	20	0.0004
40	0.0002	0.0001	0.0003	0.0002	20	0.0004
36	0.0002	0.0001	0.0003	0.0002	20	0.0004
32	0.0002	0.0001	0.0003	0.0003	15	0.0004
28	0.0002	0.0001	0.0003	0.0003	15	0.0005
24	0.0002	0.0001	0.0003	0.0003	15	0.0005
20	0.0003	0.00015	0.00045	0.0003	15	0.0005
18	0.0003	0.00015	0.00045	0.0003	10	0.0005
16	0.0003	0.00015	0.00045	0.0003	10	0.0006
14	0.0003	0.00015	0.00045	0.0003	10	0.0006
13	0.0000	0.00015	0.00045	0.0003	10	0.0006
12	0.0000	0.00015	0.00045	0.0003	10	0.0006
11	0.0000	0.00015	0.00045	0.0003	10	0.0006
10	0.0000	0.00015	0.00045	0.0003	10	0.0006
9	0.0003	0.00015	0.00045	0.0003	10	0.0007
8	0.0004	0.0002	0.0006	0.0004	5	0.0007
7	0.0004	0.0002	0.0006	0.0004	5	0.0007
6	0.0004	0.0002	0.0006	0.0004	5	0.0008
5	0.0004	0.0002	0.0006	0.0004	5	0.0008
4½	0.0004	0.0002	0.0006	0.0004	5	0.0008
4	0.0004	0.0002	0.0006	0.0004	5	0.0009
3½	0.0004	0.0002	0.0006	0.0004	5	0.0009

[4] On Go plugs, the tolerance is plus; on Go rings, minus; on Not Go plugs, minus; and on Not Go rings, plus.

[5] Allowable variation in lead between any two threads not farther apart than the started length of engagement, which is equal to the basic major diameter.

Allowances for Wear

Go plug-gages may be made larger than the minimum hole size, usually by the amount that represents the production tolerance for the gage, and in some instances a definite wear allowance is made in addition to the necessary production tolerance. Tolerances in effect in the plant with which I am connected are shown in Table 1, which gives the regular gage-maker's tolerances used for plain plug-gages, and in Table 2, which gives the ordinary gage-maker's production-tolerances and allowances for thread-gages.

The wear on Not Go gages is considerably less severe than on Go gages. Generally three Go gages will be used to one Not Go gage. No allowances for wear other than the gage-maker's tolerance is provided on any Not Go gages. There are three practices regarding the applications of tolerances to the Not Go gage, as follows:

(1) The tolerance is divided between plus and minus.

(2) Minus tolerance only is allowed on plug gages.

(3) Plus tolerance only is allowed on plug gages.

Some manufacturers split the gage-maker's tolerance on the Not Go gage. For instance, where the gage-maker's tolerance is 0.0002 in., the Not Go gage would be basic size plus or minus 0.0001 in. D. W. Ovaitt shows[6] such an application on Not Go plain cylindrical gaging-members and gives the reason why the General Motors Tool Standards Committee adopted them.

The National Screw Thread Commission's Report makes the gage-maker's tolerance minus on Not Go plug gages.

The General Motors standard specification for pitch diameter on Not Go screw-thread gages is the maximum hole size plus gage-maker's tolerance applied as follows: plus 0.0002 in. on sizes ¼ to 9/16 in., inclusive, and maximum hole size to 0.0003 in. plus on sizes 5/8

to 1½ in. The corresponding Go tolerances are from basic size to plus 0.0002 in. on sizes ¼ to 9/16 in. and basic to plus 0.0003 in. on sizes ⅝ to 1½ in.

It will be seen that by following the first and last practices we are liable to have gages that measure outside the production tolerance. However, with the general ruling that the Not Go cylindrical-gage must not pass through the hole being gaged and a ruling of a Government inspection department that a Not Go thread-gage must not enter more than two turns, it is easily demonstrated that a gage 0.0001 in. or even less under the nominal size will easily pass through a hole that is to size. This means that good work will be rejected if the gage manufacturing tolerance is minus and the Not Go gage is undersize.

As a matter of fact, under most working conditions it is possible to pass a gage through a hole that is 0.0001 in. smaller than the gage by using pressure, but this is not recommended. This condition should be taken into consideration if we are to rule that work is acceptable only when the Not Go gage does not enter, and it seems that the Not Go gage should be permitted to have a plus tolerance.

From the foregoing it is evident that the product will be little if any over the production limits if either the first or last of these practices is followed. As the wear tends to reduce the size within the production limits, it seems that the General Motors application on thread-gages is the more economical and would lead to no difficulty on properly designed parts.

It must be remembered that using a minus gage-production tolerance on Not Go plug-gages greatly reduces the working tolerance in producing the parts, particularly where these tolerances are between 0.0005 and 0.002 in. The general working tolerances for various classes of interchangeable cylindrical fits as given in the American Standard[7] are shown in Table 3, and the National Screw Thread Commission's Class-2 and Class-3 pitch-diameter tolerances for thread-gage

[7] See American Engineering Standards Committee Report B4a—1925, Tolerances, Allowances and Gages for Metal Fits.

TABLE 4—NATIONAL SCREW THREAD COMMISSION'S PRODUCT LIMITS AND INSPECTION-GAGE TOLERANCES ON PITCH DIAMETER

Pitch	Class 2[8], Product	Class 3[8], Product	Class X[9], Gage
80	0.0017	0.0013	0.0002
72	0.0018	0.0013	0.0002
64	0.0019	0.0014	0.0002
56	0.0020	0.0015	0.0002
48	0.0022	0.0016	0.0002
44	0.0023	0.0016	0.0002
40	0.0024	0.0017	0.0002
36	0.0025	0.0018	0.0002
32	0.0027	0.0019	0.0002
28	0.0031	0.0022	0.0002
24	0.0033	0.0024	0.0002
20	0.0036	0.0026	0.0003
18	0.0041	0.0030	0.0003
16	0.0045	0.0032	0.0003
14	0.0049	0.0036	0.0003
13	0.0052	0.0037	0.0003
12	0.0056	0.0040	0.0003
11	0.0059	0.0042	0.0003
10	0.0064	0.0045	0.0003
9	0.0070	0.0049	0.0003
8	0.0076	0.0054	0.0004
7	0.0085	0.0059	0.0004
6	0.0101	0.0071	0.0004
5	0.0116	0.0082	0.0004
4½	0.0127	0.0089	0.0004
4	0.0140	0.0097	0.0004

[8] On products, the maximum hole is basic size plus the amount given for tolerance on the pitch diameter and the minimum screw is basic minus the amount given for tolerance on the pitch diameter. The basic size is minimum for the hole and maximum for the screw.

[9] On Go plug-gages, the tolerance is plus; on Go ring-gages minus; on Not Go plug-gages, minus; and on Not Go rings, plus. Check gages or setting-plugs for ring gages take the same tolerance as the ring.

TABLE 3—ALLOWANCES AND TOLERANCES FOR INTERCHANGEABLE METAL FITS

SIZE			CLASS 1 LIMITS				CLASS 2 LIMITS				CLASS 3 LIMITS				CLASS 4 LIMITS			
From	Up to and Including	Mean	Hole or External Member		Shaft or Internal Member		Hole or External Member		Shaft or Internal Member		Hole or External Member		Shaft or Internal Member		Hole or External Member		Shaft or Internal Member	
			+		−	−	+		−	−	+		−	−	+			−
0	3/16	1/8	0.001	0.000	0.001	0.002	0.0007	0.0000	0.0004	0.0011	0.0004	0.0000	0.0002	0.0006	0.0003	0.0000	0.0000	0.0002
3/16	5/16	1/4	0.002	0.000	0.001	0.003	0.0008	0.0000	0.C006	0.0014	0.0005	0.0000	0.0004	0.0009	0.0004	0.0000	0.0000	0.0003
5/16	7/16	3/8	0.002	0.000	0.001	0.003	0.0009	0.0000	0.0007	0.0016	0.0006	0.0000	0.0005	0.0011	0.0004	0.0000	0.0000	0.0003
7/16	9/16	1/2	0.002	0.000	0.002	0.004	0.0010	0.0000	0.0009	0.0019	0.0006	0.0000	0.0006	0.0012	0.0005	0.0000	0.0000	0.0003
9/16	11/16	5/8	0.002	0.000	0.002	0.004	0.0011	0.0000	0.0010	0.0021	0.0007	0.0000	0.0007	0.0014	0.0005	0.0000	0.0000	0.0003
11/16	13/16	3/4	0.002	0.000	0.002	0.004	0.0012	0.0000	0.0012	0.0024	0.0007	0.0000	0.0007	0.0014	0.0005	0.0000	0.0000	0.0004
13/16	15/16	7/8	0.002	0.000	0.002	0.004	0.0012	0.0000	0.0013	0.0025	0.0008	0.0000	0.0008	0.0016	0.0006	0.0000	0.0000	0.0004
15/16	1 1/16	1	0.003	0.000	0.003	0.006	0.0013	0.0000	0.0014	0.0027	0.0008	0.0000	0.0009	0.0017	0.0006	0.0000	0.0000	0.0004
1 1/16	1 3/16	1 1/8	0.003	0.000	0.003	0.006	0.0014	0.0000	0.0015	0.0029	0.0008	0.0000	0.0010	0.0018	0.0006	0.0000	0.0000	0.0004
1 3/16	1 5/16	1 1/4	0.003	0.000	0.003	0.006	0.0014	0.0000	0.0016	0.0030	0.0009	0.0000	0.0010	0.0019	0.0006	0.0000	0.0000	0.0004
1 5/16	1 7/16	1 1/2	0.003	0.000	0.003	0.006	0.0015	0.0000	0.0018	0.0033	0.0009	0.0000	0.0012	0.0021	0.0007	0.0000	0.0000	0.0005
1 7/16	1 9/16	1 3/4	0.003	0.000	0.004	0.007	0.0016	0.0000	0.0020	0.0036	0.0010	0.0000	0.0013	0.0023	0.0007	0.0000	0.0000	0.0005
1 7/8	2 1/8	2	0.003	0.000	0.004	0.007	0.0016	0.0000	0.0022	0.0038	0.0010	0.0000	0.0014	0.0024	0.0008	0.0000	0.0000	0.0005
2 1/8	2 3/8	2 1/4	0.003	0.000	0.004	0.007	0.0017	0.0000	0.0024	0.0041	0.0010	0.0000	0.0015	0.0025	0.0008	0.0000	0.0000	0.0005
2 3/8	2 3/4	2 1/2	0.003	0.000	0.005	0.008	0.0018	0.0000	0.0026	0.0044	0.0011	0.0000	0.0017	0.0028	0.0008	0.0000	0.0000	0.0005
2 3/4	3 1/4	3	0.004	0.000	0.005	0.009	0.0019	0.0000	0.0029	0.0048	0.0012	0.0000	0.0019	0.0031	0.0009	0.0000	0.0000	0.0006
3 1/4	3 3/4	3 1/2	0.004	0.000	0.006	0.010	0.0020	0.0000	0.0032	0.0052	0.0012	0.0000	0.0021	0.0033	0.0009	0.0000	0.0000	0.0006
3 3/4	4 1/4	4	0.004	0.000	0.006	0.010	0.0020	0.0000	0.0035	0.0056	0.0013	0.0000	0.0023	0.0036	0.0010	0.0000	0.0000	0.0006
4 1/4	4 3/4	4 1/2	0.004	0.000	0.007	0.011	0.0021	0.0000	0.0038	0.0059	0.0013	0.0000	0.0025	0.0038	0.0010	0.0000	0.0000	0.0007
4 3/4	5 1/2	5	0.004	0.000	0.007	0.011	0.0022	0.0000	0.0041	0.0063	0.0014	0.0000	0.0026	0.0040	0.0010	0.0000	0.0000	0.0007
5 1/2	6 1/2	6	0.005	0.000	0.008	0.013	0.0024	0.0000	0.0046	0.0070	0.0015	0.0000	0.0030	0.0045	0.0011	0.0000	0.0000	0.0007
6 1/2	7 1/2	7	0.005	0.000	0.009	0.014	0.0025	0.0000	0.0051	0.0076	0.0015	0.0000	0.0033	0.0048	0.0011	0.0000	0.0000	0.0008
7 1/2	8 1/2	8	0.005	0.000	0.010	0.015	0.0026	0.0000	0.0056	0.0082	0.0016	0.0000	0.0036	0.0052	0.0012	0.0000	0.0000	0.0008

Class 1—*Loose Fit, Large Allowance.* This fit provides for considerable freedom and embraces certain fits where accuracy is not essential.

Class 2—*Free Fit, Liberal Allowance.* For running fits with speeds of 600 r.p.m. or over, and journal pressures of 600 lb. per sq. in. or over.

Class 3—*Medium Fit, Medium Allowance.* For running fits under 600 r.p.m. and with journal pressures less than 600 lb. per sq. in.; also for sliding fits, and the more accurate machine-tool and automotive parts.

Class 4—*Snug Fit, Zero Allowance.* This is the closest fit which can be assembled by hand and necessitates work of considerable precision. It should be used where no perceptible shake is permissible and where moving parts are not intended to move freely under load.

work are shown in Table 4. It will be noted that applying the Not Go gage tolerance in the minus direction may reduce the production tolerance by as much as 20 per cent or even more on some fine pitches with close limits.

There is no real danger from making the Not Go gage tolerance plus or minus one-half of the gage-maker's tolerance, as the permissible factor of error in work before the part fails or is not serviceable would, in all cases of good engineering, be much greater than the gage tolerance, and in those cases where this is not true a special set-up for gaging such accurate parts would have to be made anyway.

Periodical Inspection of Gages

Parts rejected in the general run of inspection are entitled to reinspection with gages that give the full benefit of the maximum and minimum part size. As stated before, it is good practice to have gages inspected for size when they are put on the job and at regular intervals thereafter. In the case of continued runs, inspections should be made at intervals depending on the amount of wear that is found by experience to occur. In some cases it has been found necessary to inspect gages every hour, in others after five hours, once a day, or once a week in order that gages worn beyond set limits should not be used.

A belief exists to some extent, in connection with checking rings by means of plugs, that a plug will not enter a ring of the same size. The fact is that metal is elastic, and a plain plug and ring of the same size will go together quite readily. In fact, the plug may be slightly larger than the ring, with the ordinary amount of lubricant that is on the gage, and it will require only the amount of pressure that would be ordinarily exerted by the operator to have them come together. They will come apart quite readily if not allowed to set too long. We all know that a drive fit of 0.0001 in. or less would not be very effective, so that gages which come together without any looseness are substantially of the same size. It has been demonstrated in connection with size blocks that the oil film is extremely thin, so that plug gages or setting plugs can be used for establishing sizes without any allowance being made in the size.

Setting-plugs to which adjustable gages are set should be made so that the gage will be safe for the job on which it is to be used, as there is naturally no wear allowance on adjustable gages. This applies to check gages for rings and ring thread-gages where the Go check is made with the gage-production tolerance applied in the minus direction. We have the same variation in practice on the setting-plugs for the Not Go ring-gage as we do on the Not Go plug-gage. In general, the Not Go setting-plug is made as near the Not Go size as is practicable by splitting the tolerance. In this case the National Screw Thread Commission's Report calls for the Not Go check to be made with a plus tolerance.

Measurement of Gages

In checking gages for wear, measurements are an important factor. In general, soft gages do not make accurate measurement possible, principally because it is difficult to obtain a flat, smooth finish and also because, on account of the soft nature of the material, the measuring surfaces are apt to sink in to a certain extent. This is particularly true in measuring soft threads with wires.

Errors in reading micrometers and measuring-machines are usually less than the errors in the instruments themselves; that is, you may be able to read the micrometer to a fraction of 0.0001 in., but the inaccuracies in the micrometer screw or the anvil surface may be as much as 0.0001 or 0.0002 in., because of wear.

Pressure in making measurements is an important factor, particularly in the use of balls, rolls or wires. The practice approved by the Bureau of Standards for wire measurements of threads is that threads finer than 20 per inch are checked with a measuring pressure of 8 oz. and threads 20 per inch and coarser are checked with a pressure of 3 lb. The Bureau recommends that the wires be calibrated, crossed over a roll 0.750 in. in diameter. Pressure is important also in checking taper ring-gages. The gages should be thoroughly cleaned and the test plug inserted until it seats, no pressure being applied. Taper plugs are usually checked with wires or rolls.

Temperature is a factor in checking large work. Bearing in mind that the change in dimensions of steel due to temperature is approximately 0.0001 in. for each degree in a length of 16 in., the importance of the temperature factor can readily be determined for a particular job. A difference in temperature of 1 deg. fahr. would take up the full tolerance in a gage 32 in. long with a tolerance of 0.0002 in.

Testing for Gage Wear

In measuring the gage for wear, it is important that the checking tools reach the actual point of wear in the gage. For instance, a snap gage with flat anvils on one side and round anvils on the opposite side, used on gaging round shafts, has a tendency to wear a groove through the flat anvil. These gages cannot be accurately reset with plugs until the flat anvil has been lapped to remove the groove.

Thread-gages, which wear more rapidly at the crest of threads, offer another example. Ring thread-gages that show practically no wear when checked with a setting-plug having the basic outside diameter will frequently show considerable wear when tested with a check plug that is truncated to 60 per cent of the full depth.

These inequalities of wear on the gaging surface cause most of the disputes between the production and inspection departments. Two gages may appear to be of the same size according to the check plug and still, because of inequalities of wear on the gaging surface, differ radically in the work that they will pass. The wear of plungers on indicating gages, giving them a slight side movement, is a frequent source of error.

Worn gages should be rejected when they have reached the wear limit that has been set up. In the case of Go gages, this should be basic size, although in some instances it is economical to permit an undersize condition. A definite figure should be set for each case, and there should be a definite period for gage inspection so that the gage will be withdrawn from production use at the proper time.

The Future of Tungsten Carbide as a Cutting Tool

Production Meeting Paper . . . . . .

By William H. McCoy[1]

AFTER making references to a number of articles on tungsten-carbide tools, the author describes the incident that aroused the interest of his organization in the material. In this case, the new tool machined 15,000 pieces per grind instead of only six pieces. The savings realized on a number of other jobs are tabulated. Some classes of work are enumerated in which failures have been encountered, and some causes of these failures, and remedies for them are said to be found in large tips and annealed shanks.

As no one type of tool steel has been found suitable for all jobs, the author predicts that a number of varieties of tungsten carbide will be developed, differentiated by modifications in the binder and graduations in the grain sizes of the tungsten-carbide particles. This will make it possible to select a tool material suitable for the job, instead of picking out jobs that can be done by the material.

CONSIDERABLE information has been published in the past regarding the manufacture and general properties of tungsten carbide as tool material. The purpose of this paper is to give some idea as to what may be expected in the future development of cemented tungsten carbide for this purpose.

Those who are interested in learning of the advantages to be derived from tungsten-carbide tools in the present state of development can find much of interest in the following articles: By Dr. Zay Jeffries, of the Aluminum Co. of America, Present Status of Cemented Tungsten-Carbide Tools and Dies[2]; by Dr. S. L. Hoyt, of the General Electric Co., Hard-Metal Carbides and Cemented Tungsten-Carbide[3], Preparation of Microsections of Tungsten Carbide[4], Carboloy and Tungsten-Carbide Tools[5], Harder Metals Are Now Workable with Cemented Tungsten-Carbide[6], Carboloy—A New Tool Material[7]; by F. C. Spencer, of the Western Electric Co., Present Status of Tungsten Carbide as a Cutting Material[8]; by H. J. Long and W. P. Eddy, of the Brown-Lipe-Chapin Co., Tungsten-Carbide Cutting-Tools[9]. Earlier articles on the subject of tungsten-carbide tools may be found by reference to a bibliography that has been printed in the production-engineering department of the S.A.E. JOURNAL[10].

Some results obtained in our own divisions illustrate further the present status of this cutting material. In December, 1928, we placed a tool in one of our divisions on the job of turning a ferrule, which had caused no end of trouble. This ferrule was a die casting having a hard, chilled surface. The adoption of a tungsten-carbide tool increased the production from six pieces per grind to as high as 15,000 pieces per grind. The turning speed was also increased, from 750 to 1400 r.p.m., the latter being the maximum speed attainable on the machine. This job aroused our interest in the new cutting-material, and we have been working with it since that experience. Some results attained with tungsten-carbide tools, in comparison with those with high-speed-steel and Stellite tools, are shown in Tables 1 and 2.

We have received a report from a company not affiliated with our corporation stating that it had successfully used tungsten carbide for turning stainless-steel drums or cylinders, 40 in. long and 18 in. in diameter, accomplishing a net saving of $26.25 per piece.

A very interesting folder recently put out by the Disston Saw Co. showed its circular saws of different types tipped with tungsten carbide. It claims that very large savings have been accomplished by the adoption of these tips.

The savings cited in the foregoing are very impressive, but we have found that similar savings are not possible on all classes of work, because certain shortcomings of this material make it necessary to confine its use to machining specific materials and to specific conditions. For instance, we have had very little success with tungsten-carbide tips on twist drills; and tools have failed because of chipping of the tungsten carbide on some automatic-screw-machine jobs, as a result of shock or intermittent cutting.

Preventing Failures from Heat

As cemented tungsten-carbide has a high heat conductivity, higher than that of the shank material, when tungsten-carbide tools are cutting a material which generates a great amount of heat two things are liable to happen; first, the shank gets very hot and expands away from the tip, breaking the bond, and, second, there is a tendency to alloy between the chip and the excessively hot cemented tungsten-carbide. This latter effect is particularly noticeable when cutting soft steel and not so noticeable when cutting steel which is in the Brinell range of 220 to 260. It has been noticed

---

[1] M.S.A.E.—Manager, research experimental production machine-shop, General Motors Corp., Detroit.

[2] See *Iron Trade Review*, Oct. 10, 1929, p. 909.

[3] See *Iron Age*, Feb. 27, 1930, p. 646.

[4] See *Transactions of the American Society for Steel Treating*, January, 1930, pp. 17 and 54.

[5] See *Machinery*, February, 1929, p. 457.

[6] See *Automotive Industries*, Nov. 2, 1929, p. 653.

[7] See *General Electric Review*, November, 1928, p. 585.

[8] See *American Machinist*, May 30, 1929, p. 865.

[9] See *Iron Age*, May 23, 1929, p. 1414.

[10] See S.A.E. JOURNAL, September, 1929, p. 307.

that a small fin appears on the cutting edge, when cutting soft steel, and that this fin breaks off and takes with it a small portion of the carbide tip. This action is believed to be caused by the fact that the heat generated is sufficient to raise the temperature of the extreme cutting-edge to a point at which actual alloying takes place between the chip and the cutting edge of the carbide. The alloy produced is brittle and breaks off, thus causing early failure.

Such effects can be overcome with the present alloys by increasing the size of the tip enough to cause the heat to be conducted away rapidly, so that alloying temperatures are never attained under ordinary working conditions. We also find it advisable to remove the machining strains in the tool shanks before mounting the tungsten-carbide tips. After the machining of the recess is completed, these strains should be removed by packing the shank in a charcoal-pot, heating to approximately 1750 or 1800 deg. fahr. and allowing it to cool slowly. This procedure seems to eliminate most of the difficulties that we have experienced with the tips from cracking after the bonding. Such cracks do not appear until after the tips are finish ground.

It is our belief that a large number of grades will be developed for the differentiated application of this material as a cutting tool, in much the same way as high-speed and alloy steel of various compositions have been developed for various applications.

We all know that different alloy-steels are used for different purposes. We use a medium-tungsten, high-speed steel for hot-extrusion dies, whereas high-tungsten-cobalt high-speed steel is, at the present time, used for many machining operations. Similarily, it has been found that high-carbon, high-chromium steels, particularly those containing small quantities of vanadium and molybdenum, are very desirable where extreme resistance to abrasion is required, as in cutting and forming. This steel is not particularly adapted for tools and dies that are subject to severe transverse stresses. In other words, it has been found that no one steel will satisfactorily meet the needs of all applications. It has recently been demonstrated that a single type of tungsten carbide has as little chance of meeting the requirements of all applications as has one type of steel.

TABLE 2—SAVINGS RESULTING FROM REPLACING STELLITE TOOLS WITH TUNGSTEN-CARBIDE TOOLS FOR LATHE WORK ON CAST IRON

Operation	Production, per Day	Cost per 100 Pieces: Stellite Tools	Cost per 100 Pieces: Tungsten-Carbide Tools	Savings, per Month
Face flange	2,400	$5.83	$3.14	$1,166.82
Face, turn, chamfer	200	15.28	3.36	452.00
Turn, face, chamfer	500	24.69	8.37	1,589.60
Face, turn, face hub		8.35	6.50[b]	

[b] Tool has never been sharpened and is still running.

Alloying the Binder for Strength

The low transverse-strength of tungsten carbide has been responsible for the breaking down of the cutting edge of the tools in all of the cases cited, in the final analysis. A realization of this fact is directing the development of cemented-tungsten-carbide alloy along two distinct lines: (*a*) development of new physical properties to meet certain specific applications by the use of binders other than cobalt; and (*b*) development of cemented tungsten-carbide possessing diverse physical properties by regulating the size of the carbide particles which are to be bound by the alloy binders.

Alloying cobalt by the introduction of small quantities of such elements as copper, nickel and tantalum has been found to exert a most profound effect upon the physical properties of the cemented tungsten-carbide containing them. However, these alloys are only in the experimental stage. The addition of various elements exerts a most profound effect also upon the strength, elasticity, hardness, and other physical properties of steel, according to the character and quantity of alloy used. The possibilities of such alloying can be understood when we realize that cemented tungsten-carbide consists of from 87 to 97 per cent of tungsten carbide bound by an alloy of cobalt, and that the strength of the material is determined by the character of the alloy binder.

It is therefore reasonable to expect that the small additions of metallic elements would have a greater effect on the physical properties of tungsten carbide than on alloy steels.

A second series of alloys will undoubtedly make its appearance also, the difference in the properties of the different grades of this series depending upon the grain size.

TABLE 1—SAVINGS RESULTING FROM THE USE OF TUNGSTEN-CARBIDE TOOLS

Machine	Material	Operation	Pieces per Grind: Cutting Speed, F.P.M.	Depth of Cut, In.	With Tool Replaced	With Tungsten-Carbide Tool	Saving, per Month
Substituted for High-Speed-Steel Tools							
Milling	Aluminum	Finish mill	933	0.015	34	1,013	$1,450
Lathe	No. 32 Bronze	Groove	294		20	4,000	576
New Britain Turret-Lathe	Cast iron	Drill	45		206	16,400	140
Warner & Swasey Turret Lathe	No. 32 Bronze	Bore	157		10	1,064	300
Substituted for Stellite Tools							
Lathe	Cast iron	Finish face	196	0.032	1,500	15,000	200
Drill-press	Babbitt	Rough bore		0.093	400	40,000	350
Lathe	Alloy cast-iron	Turn outside	98	1/8	5	89	30.96[a]
Boring-mill	Cast-iron	Bore	98	1/8	7	89	31.96[a]
Lathe	Alloy cast-iron	Face back of brake-drum	(A saving of 80 hours was accomplished on one set-up)				

[a] Saving per tool.

The size of the carbide particles to be cemented by the metallic binder is of the utmost importance where fine cutting-edges are required. The grain size varied in the early tungsten-carbide and attempts were made to make the grains finer. An effort has recently been made to control the size of these fine particles, and experiments have been conducted which indicate that control of particle size will exert a very great effect on the hardness and strength of the finished product. One manufacturer has experimentally produced cemented tungsten-carbide all of the cemented particles of which are of approximately the same size. Experimental tests of this material indicate that it possesses strength equal to that of fully hardened high-speed steel. The principle involved in this regulation of particle size seems to indicate that greater strength results when the particles of carbide are sized so that the minimum amount of cement is between the grains.

The conclusion of our findings is that in the future we shall undoubtedly see many different grades of cemented tungsten-carbide. In other words, a grade of tungsten carbide will be developed to suit each particular job, thus obviating the present necessity of finding a job to suit the tungsten carbide.

In view of our experience and the possibilities of the future, we can see no reason why this material will not replace high-speed steel as a cutting-tool to the same extent that high speed steel replaced carbon steel.

Motorcoaches Designed and Built by an Operator

(*Concluded from p. 547*)

by connections between these two areas. It is now in the experimental stage and the performance seems to be satisfactory.

MR. SCARRATT:—In case of rear-tire trouble, what practice is followed?

MR. MOORE:—Replacement of a rear tire is no more difficult than it would be on any other coach of similar size. Changing a tire at night presents no unusual difficulties. A saddle is provided for the hydraulic lifting-jack to engage and thus minimize the danger of slipping. The vehicle has a bulky appearance, but it is not nearly so heavy as some of the other types of parlor-car because the bulkheads and the exterior and interior panels are made of duralumin.

MR. POOLEY:—What is the approximate electric-lamp load?

MR. MOORE:—The coach has approximately 50 lamps, a 750-watt generator and two batteries. It has a 12 to 16-volt electrical system and we have no difficulty in keeping the batteries fully charged with that size of generator.

Method of Heating Stated

MR. SCARRATT:—Was the Nite-Coach body developed particularly for use in the California climate or can it be used in any climate where motorcoaches would be operated at night? What provision has been made to provide the necessary degree of warmth of wall structure that will enable passengers to be comfortable?

MR. MOORE:—We have used an insulating material to make the vehicle comfortable in cold weather, but I find that we must go further. We have been heating the coaches by utilizing the ventilating system, taking the cold air from the roof in front, bringing it down through a channel and driving it by means of a fan into the various compartments after the air has been heated by passing through a hot-water radiator. The water in the radiator is heated by the engine, being connected with the circulating system, but this does not produce enough heat and we are now building a separate heating-plant to heat the water.

We also find it necessary to insulate the side of the coach, not because it radiates cold but because it feels cold if the passenger touches it. So we expect to cover the side with some sort of fabric and may go even farther toward insulating it completely.

MR. FERGUSON:—How does the operation cost of the Nite Coach compare with that of a coach which operates during the day?

MR. MOORE:—We have been operating in the day time for many years; our regular fare is $11 and the $3 cost for night service is merely added to the fare. We have not yet completed our cost study of the Nite Coach and, therefore, I am unable to state the total operating-cost.

Among the unusual extras is the expense of laundering. Each coach carries a steward and porter. For the last three years, we have served meals in the parlor-buffet coaches between Los Angeles and San Francisco, but the concession was operated by an outside company we have found this more satisfactory than to attempt to operate dining service ourselves. The stewards buy the food and they are their own merchants. They sell at a profit, but we limit them to specified prices that they can charge for certain dishes and then allow them to sell as much food as they can.

As to the mechanical maintenance-cost this has been less than for any other type of vehicle of a comparable size that we have ever operated. We feel that the depreciation cost is about 5 cents per mile.

MR. HORNER:—Is the driver in command?

MR. MOORE:—Yes. The service has been in operation somewhat over four months. The steward and the porter are employed by the outside company which operates the dining-service concession, and they are answerable to the operating officials of that company. The steward tends to the ticket collection, cares for the passengers and their baggage and sees that they get off at their desired destination.

Airplane-Spin Symposium

Numerous phases of airplane spinning-characteristics and control were discussed at the 1930 Chicago Aeronautic Meeting. Six papers were presented, and they are printed herewith. An abstract precedes each paper, so that readers can glean the major trends of the opinions expressed.

The general subject is treated from varied angles of attack by Lieut. Carl Brown Harper, Paul E. Hovgard, Temple N. Joyce, Garland P. Peed, Jr., Harry A. Sutton and Fred E. Weick.

Why Airplanes Spin

By Lieut. Carl Brown Harper [1]

THE SPIN is characterized by the author as being an outlaw. Flight maneuvers are considered as being abnormal, normal and not wholly normal. The history of the spin includes loss of control, reversal of control, and the controlled spin. Poorly qualified designers and inertia distribution are the author's subdivisions of inadequate design, and he discusses also the bad spinning characteristics of training, fighting, observation and commercial airplanes in considerable detail.

The corrective analysis presented includes frantically made corrections and corrections made after careful testing. Under the former heading British, German and American efforts are cited, as well as the results from the method of trial and error, in which the center of gravity was relocated, the tail surfaces modified, the wing sections juggled, or the altering of wings at their tips was tried. The theoretical spin-characteristics of the monoplane and the biplane are contrasted, tail blanketing is mentioned and the scarcity of qualified experts for full-scale testing is stated. As to careful testing, full-scale tests by the Army and the Navy and by individual companies are commented upon.

The recognized types of spin are stated as the normal, the vicious-uncontrolled, and the peculiar. The characteristics of single-seater and of two-seater fighting-observation airplanes are discussed, and the testing of an improved wing-slot on a Corsair airplane is described.

THE spin is an outlaw; once an abnormal flight maneuver, then a normal one, it is not now a normal maneuver. For a long time it was an unrecognized non-understandable flight maneuver. The early airplanes were not always statically stable, but more often were dynamically unstable. The pilot flew the airplane every instant, because relaxing of concentration resulted in loss of control which was sometimes permanent and, sometimes, control was regained. Pilots were usually badly injured, but were not often killed as the result of a spin. Those that lived were curious.

They found that, below a certain speed, the controls produced an exactly opposite response to that expected when used in the usual manner. A wing that was going down continued going down despite the fact that the aileron was set to lift the low wing. The elevator in full up-position failed to raise the nose. This loss of control was then recognized as a *reversal of control* for a certain speed range. Planes falling out of control had been observed to take a twisting downward path with the plane rotating on this path. To this phenomenon was assigned the word *"spin"* since the airplane seemed to be spinning about an axis in its downward path. Now that the control was recognized as *reversed*, it was no longer *lost;* therefore, pilots found that, although the nose was down, by pushing the controls forward as for down elevator, flying speed was resumed, response became normal and recovery then became normal.

As late as 1917 many of our military and civilian flight instructors were totally ignorant of the spin. In certain instances these instructors, while experimenting with maneuvers or acrobatics, inadvertently fell into spins. More often the planes were put into spins by students. Instinctively, when every other means failed to result in resumption of normal flight, the controls were put into neutral because "that was all that was left to be done." Fortunately, in the type of training plane most in use, that was all that was needed to bring the plane out of the spin.

Controlled Maneuvers and Design

The next step was to study the spin as a *controlled maneuver.* As a result, pilot instructors became very adept in spinning. By the use of various amounts of aileron control, planes were made to rotate in a spin about the inboard struts, or the outboard struts, or the wing-tip. Students were required to make a very definite number of turns in a spin and to emerge precisely at predetermined points in the path of rotation. It was soon learned within the precision of 100 ft. what altitude was lost in a specified number of turns and how much altitude it was necessary to recover. All of the foregoing experiences occurred in the days of light wing-loading and in airplanes of a similar conventional type, so-called. The spin was no longer a mystery; it was *a controlled normal maneuver.*

[1] S.M.S.A.E.—Recently attached to the Bureau of Aeronautics, Navy Department, City of Washington; now retired.

In recent years heavier demands have been made upon airplanes, particularly upon military airplanes. Navy demands, where the size of an airplane for stowage and use on shipboard is important, caused a greatly increased wing-loading with narrowed wing-span and close coupling of wing and tail. The radial air-cooled-engine development produced different and new inertia moments in the airplane. Designers departed from the conventional types. Wind-tunnel tests were sometimes made for static stability but, more often, they were not made nor were dynamic and spinning wind-tunnel tests made. The overnight growth of the airplane industry resulted in a group of designers who knew just enough of aerodynamics to be dangerous. They were so sure of themselves that they did not need the wind tunnel. Test pilots were cheap.

Puzzling Loss of Control Experienced

Once again pilots reported *loss of control*. Airplanes were wrecked, one type being a training plane with wing loading much greater than that of the old training-plane types but, fortunately, less than that of the fighting types. Some of the best Air Service test-pilots tried to learn how to master the spin of this plane, but they did not always bring it out of the spin. Another plane of the fighting type developed spin characteristics that resulted in a crash in which the pilots were killed. One pilot lived long enough to tell how he tried to pull himself from the cockpit to jump with his parachute, but said that he was not strong enough to overcome the force that was holding him in. This spin was different from that of the training plane mentioned. Similar, but somewhat less vicious conditions, developed in commercial planes.

LIEUT. C. B. HARPER

A large observation plane had been experimented with in detail. Full-scale tests with loads arranged for different mass-distribution checked in most instances with the mathematical assumptions which had been made. One authority announced that biplanes were the offenders and advocated the building of monoplanes to remove the cause of the bad spin. But the monoplane furnished a sharp reproof; it had bad spinning characteristics, and so did other monoplanes built subsequently. Outward sideslip had not been taken into account. Wise heads suggested probable remedies. Would-be wise heads said: "Try this" and "try that."

The Department of Commerce issued a severe requirement to make sure that commercial pilots would not be in a position to be tempted to try this kind of spin in airplanes, and granted approved-type certificates. An effort was made to collect data on the proper location of the center of gravity. As a result, the spinning characteristics of a number of small commercial airplanes were improved by moving the center of gravity forward. Inadequate weight-control during construction had allowed over-weight to creep in, which resulted in the inevitable tail-heaviness that tends toward static instability. Therefore, tail areas were altered. A British formula which allowed for the blanketing of the vertical surfaces by the shadow of the horizontal surfaces on the vertical tail-surface at high angles was applied. But this proved the fallacy of depending upon a special rule. One of the resulting planes having the worst spinning characteristics had a normal coefficient. Test pilots were killed, but certain facts emerged and spinning characteristics were improved.

Experts on spinning characteristics then developed, the public became "spin conscious," and the danger of promiscuous spinning was recognized. But inevitable disadvantageous features became evident. The experts became so expert that they deceived themselves. They concentrated on a given type of plane. Certain so-called experts juggled weights, made small changes in areas and got what they and their engineer advisers thought were "results." They were aided in this involuntary self-deception by relatively light wing-loading where spins were not really *vicious*, in the full application of the term; therefore, they reached conclusions which are unsound. The solution fitted only a certain plane. An analysis of most of their published conclusions shows a certain groping, and there is a glaring lack of repetition of tests which will give a positive conclusion.

Spinning Is a Variable Effect

The pilot has failed to realize that forces not only beyond his knowledge but also beyond his control are present to keep him from duplicating the special type of spin he desires. It is assumed that he is familiar and skilled enough to know what type of spin he wishes to select. When the pilot says that small changes in weight or in areas have materially altered the spinning characteristics of a vicious spinner, it means that the pilot does not know how to spin the airplane.

Test pilots and engineers have stated that planes have emerged from vicious spins when the pilot stood up to climb out preparatory to going over the side. The instances in particular have been with military planes. One reason they have given has been that the change in the center of gravity of the airplane caused it to come out of the spin. A rough calculation of the change in the center of gravity or inertia moments as a pilot stands up in the airplane will show how very small these changes are. Since the spin itself cuts off the streamline flow of air over the tail, the pilot's projection into the disturbed air is inconsequential.

What has actually occurred is that, when the plane has been left alone long enough with free controls, it has itself come out of the spin. The pilot may have been trying the wrong control-combination. He may have been spinning so fast that he was confused as to direction of spin. He may have been holding the stick back and trying to bring the nose up. The inertia forces in a fast-spinning airplane are so great that, it is obvious to anyone familiar with these spins, no very slight change will alter its spin characteristics so as to result in recovery, once the spin is well developed.

Recognized Types of Spin

Spins can be divided into normal, controlled spins and vicious, uncontrolled spins. The normal, controlled spin can be (*a*) slow and either steady or cyclic; (*b*) fast; or (*c*) of the spin-spiral type. The vicious, uncontrolled spin can be (*a*) flat and either slow or

fast; or (*b*) it may be peculiar. The various types and their subdivisions are best described by examples.

The early war-training type of plane was a good example of the normal, controlled spin. At all stages of the spin the pilot could feel ready response to his controls and knew that he could emerge by a prescribed use of his controls. There were and are today types of plane that possess the cyclic type of spin characteristic in which, in every half-turn, the plane will try to come out of the spin.

On one particular type of military plane, three distinct types of spin may occur, the different types occurring when flying the plane under the same conditions of load and trim. A heavier loading makes the vicious spin somewhat more vicious.

A given type of spin is determined by the manner of entry into the spin and by what is done with the controls after the spin starts. As a rule, after practice, the type of spin can be decided upon in advance and can be selected by the pilot; but, in shading selections to endeavor to pass gradually from performing one type of spin to try another type, the ability to select the type desired disappears at times. A little too much forcing may result in a vicious spin instead of producing the gentle spin desired.

Entry into a Vicious Spin

The manner of entry for the vicious type is to set the throttle at 1200 r.p.m., then to "snapstall" by bringing the stick all the way back. Apply sharply hard left-rudder so that it will come hard-over just after the stick comes all the way back. The controls must be held all the way. The nose will start to drop gently; then, very suddenly, it will whip down and carry over so that the plane goes partly on its back.

The spin starts slowly with the nose turning in a wide circle but, by the time a half-turn is completed, the radius of this circle is practically zero and the nose is turned nearly vertically down. By the time a three-quarter turn is made, the speed of rotation has become very fast. The rudder loses its "bite" entirely and can be kicked from side to side as though the plane were resting on the ground with no slipstream effect. The reaction is zero. The stick then begins to push itself back into the pilot's belt. This reversal of stick force increases, and it requires considerable effort at the end of the fourth turn to push the stick forward.

At the fourth turn the nose of the plane starts to come up from the vertical, but it does not come up to less than 60 deg. with the horizon. The elevator has become very ineffective. With full-opposite rudder and full-down elevator, the plane will come out in from three to four turns. To the pilot, the ground seems to be turning around so fast that it is merely a blurred line.

In a prolonged spin of the vicious type it is necessary for the pilot to decide before he enters the spin what controls he intends to use to emerge from it. He must keep this control combination paramount in his mind. The feel of the ship and its reaction in the spin is unnatural and dangerously bewildering. It is difficult to count the turns by looking at an object on the horizon some distance away. These turns build up speed; at the end of the fifth turn the rotation of a Corsair airplane with a 4200-lb. load is faster than one turn per second. On the other hand, if the stick is allowed to go forward as little as 2 in. the spin, if still in its first three-quarters of the first turn, will develop into a spin-spiral, which will become a steep spiral during the fourth turn.

A vicious spin may be a flat spin or a fast spin with reversal of stick forces present, together with a resultant unhealthy feel to the ship. The flat spin of the slow type develops in the third or fourth turn of what starts out to be a normal spin. The nose comes up, relative to the horizon, and the rotation continues at a slow rate. The rudder is lost first, and the flippers may be waggled just as though they were in dead air. Recovery is made as from the vicious spin of the peculiar type.

Normal Type of Spin

In the gentle, normal type of spin the controls tend to neutralize and, if they are brought into action in any part of the spin, they are at once effective and the response is normal. The normal feel of the ship is present. The rate of rotation may be smooth and slow, or it may be smooth and fast. It may be steady, or the plane may spin in a series of half-turns wherein the action and even the "feel" is that of a sine-wave curve. The rotation slows up in a half-turn, and the nose goes down relative to the flight path. With the stick held back, however, the plane stalls again and then picks up speed until this cycle is repeated.

A single-seater fighting type of plane was said to be incapable of being forced into a vicious spin; *yet it was spun, flat.* Another plane of the latest single-seater fighting type has been put into spins by pilots. The spins were reported as being bad. In one instance, the plane came out of the spin after the pilot had abandoned the controls and was ready to take to his parachute. Another pilot said he never wanted to get it into another spin. Very recently, a skillful military pilot got one of the latest pursuit-airplanes into a spin, and had to get out of the spin with his parachute. A service pilot was trying to demonstrate the spin characteristics of a Corsair airplane. He spun three turns to the right successfully but when he tried to spin three turns to the left he had to take to his parachute. These pilots were incompetent spin pilots.

A spin should be practised while training a pilot so that he learns what to do and how to avoid becoming bewildered or confused in case his plane falls into one. Fighting airplanes should be capable of two turns with normal recovery. As a maneuver a spin should not be countenanced. Too many other desirable flying qualities must be sacrificed to assure normal spinning.

The inertia of inherited instinct which impels one to dodge objects to save oneself cannot be overcome in a day; yet with present airplanes a pilot is told that he must reverse his normal instinctive actions and disobey his instincts in an emergency when time for thinking and reasoning is very short. He must nose down into an obstruction in case his engine quits while taking off rather than pull up over it or go around it. Crash after crash has proved the inadequacy of this teaching. Even the most experienced pilots obey their natural impulses and stall into a spin. A prolonged spin provides a steady target for a plane diving toward it, and the pilot who emerges from a prolonged spin is not as physically acute as when he entered it.

Wind-Tunnel Tests Advocated

Designers must make use of wind-tunnel tests. There are too few competent test-pilots available. The older pilots with the necessary experience to interpret their

results intelligently say frankly that they do not care for this type of spin testing. The chance of escape by parachute from a well-developed vicious spin is slim. The pilot must be so familiar with the plane and so skillful in spin testing that he is able to decide just how far to let the plane go before he starts to bring it out of a vicious spin, and situations will arise in which he will miss his guess.

The bad spinning features of one of the planes in Air Service use have been improved. The tail was lengthened, the size of the elevators was increased, sweepback was incorporated in the lower wing, and the center of gravity was moved forward.

Pressure-Distribution Investigation

Two factors stand out from a spin of the latest wing-slot on a Vought Corsair airplane. The forces in a fast vicious spin are such that pressure distribution should be investigated on wing sections at very high angles of incidence. The wing-slot does more work in helping to bring a plane out of a spin than has been credited to it.

To go somewhat beyond what might be experienced with a normal load, 150 lb. of sand was added to the baggage compartment behind the rear cockpit. The plane was maneuvered so that it was forced into a fast vicious spin. As the plane went over onto its back in the start of the spin it went so far that, when the rotation started, the controls had not only an unnatural "feel" but a more than usual feeling of unnaturalness. The controls were reversed so promptly that an inverted spin developed. In the next attempt the spin that resulted was the most vicious one so far encountered; in fact, the sand in the tail did its work better than was expected. When the slots were unlocked in the fourth turn, the slot on the inside wing came out against the stops and caused a considerable jar. The plane emerged in less than a turn. (The controls were set to help bring the plane out.) The slots would not close so that they could be locked to try another spin. An examination showed that the supporting links had been bent back, although these links had been designed for a load factor well over the requirements.

My paper on Airplane Spins and Wing-Slots[2] gives a technical analysis of spins and design suggestions.

[2] See S.A.E. JOURNAL, July, 1929, p. 25.

Experiences With Spins

By Temple N. Joyce[1]

THE author relates his experience with spins which began at Issudoun, France, in the spring of 1918 with a Nieuport training airplane. This includes tests made in 1928 following the crashing of two Navy observation airplanes to determine whether the airplane really had bad spinning characteristics and if so, what changes were necessary.

Installing a new set of control surfaces with an increase of approximately 50 per cent in the elevator area and about 20 per cent in the rudder improved the normal-flying control but did not improve the rolling condition of the airplane because after executing one complete roll the airplane still came out rolling, yawing and pitching regardless of the opposite-control position. To reduce the stick forces a balance was placed on the flippers which increased the total area 2.2 sq. ft. This change brought about a radical difference in the point at which reversal of stick forces occurred.

From these and other tests the author concludes that many apparently normal-spinning airplanes might be made to spin abnormally and produce a delayed-recovery condition, depending upon the manner in which the spin is entered. The term flat spin should be discontinued because it is misleading and some differentiation should be made between stable autorotation as applied to a wing cellule and autorotation as applied to a complete airplane. Terminology for the various types of spin should be developed by the National Advisory Committee for Aeronautics which now classifies them all under one broad heading.

MY first knowledge of the existence of several kinds of spins was in France in the spring of 1918 when we found that an 18-m. Nieuport could be made to spin either normally or abnormally, according to the manner in which the spin was entered. The recovery too was very different but we did not realize at that time, nor until a few years ago, how significant this fact was. Later I want to bring out the relation between this fact and what has been brought out in recent years and attempt to explain some of their influences on crashes during the entire period.

The primary-training Nieuport was a dual-control airplane with an 80-hp. LeRhone engine and 23 sq. m. (247.572 sq. ft.) of wing area. To have a transition airplane between this and the little 15-m. that was used for pursuit training, the 18-m. was developed. This consisted of the same fuselage, tail surfaces, landing gear and engine as the 23-m. except that the wing area was only 18 sq. m. (193.751 sq. ft.) instead of 23 sq. m. (247.572 sq. ft.).

At Issudoun, the Army pursuit school in France, students were given primary training on 23-m. Nieuports or, if the pilot came from America with a certain number of solo hours in Jennies, he was given a few refresher flights on the 23-m. and, after checking, both classes of students were passed on to the 18-m. airplane with the front cockpit closed in. In this stage a student made solo flights, a few cross-country hops and then advanced to another field where he was taught spirals in the same type. Later if he passed the spiral class, he was given time on a 15-m. Nieuport with 80-hp. LeRhone engine, then the 15-m. with 120-hp. LeRhone and finally combat and aerial gunnery instructions in all different types of airplane that were being used on the front. On the 18-m. stages more pilots were killed than at any other field and most of them

[1] A.S.A.E.—Vice-president and general manager, BJ Aircraft Corp., Baltimore.

in the spiral class, where a student, having been shown how to use the controls on the ground, went up solo and attempted to execute spirals. Most of the French instruction in acrobatics and spirals was to sit on the ground and tell the student how to move the controls, and we would go up and try it. Time after time students spun in from varying altitudes and in most instances from sufficient height to be able to recover.

Flat Spins

Early in the spring of 1918 I learned from one of the French instructors at the field how to execute what was referred to as a flat spin on the 18-m. Nieuport. To spin normally the throttle was retarded and while in level flight the stick was gradually brought back to the rearmost position and just as the airplane stalled, right or left rudder was added as desired and the airplane spun perfectly normally with the nose well down. Recovery was possible immediately. To flat spin power was left on while the airplane was flown in horizontal flight, approximately slightly below cruising speed, and contrary to the first instance the rudder was kicked violently after which the stick was pulled back. This apparently imparted a high rotating motion to the masses of the airplane and a stall was brought about afterward by pulling on the stick. The airplane spun perfectly flat and to recover giving full throttle and holding the stick well forward with full opposite rudder was necessary.

I remember, after having made faithful promises to the Frenchmen not to tell anyone how the trick was done, going up and acting smart by showing how one could do either a normal or flat spin in an 18-m. Nieuport, never thinking that maybe the engine might stall and recovery thereby be made impossible.

About five years ago we again began to hear about the improperly termed flat spin and I refer to it as improperly termed because the same aerodynamic conditions might exist with the fuselage very flat or almost vertical, the two conditions being exactly alike in that recovery is difficult and in most instances accompanied by a reversal of stick forces.

Delayed-Recovery Spins

Not until 1928 did I really have any actual experience or opportunity to study delayed-recovery spins. In the summer of that year two Navy observation airplanes crashed at Newport with pilots of wide experience, one having been flying for 10 years and the other having been out of the Pensacola training school for over a year. The first pilot to be killed, Lieut. H. N. Wilkinson, was the older, and from reports the airplane crashed in a flat attitude with the pilot out on the wing. Apparently he had decided beforehand that recovery was impossible and had stepped out on the wing with the idea of jumping, but crashed before this could be done. When the airplane landed the pontoon was twisted some degrees from its normal position and apparently the engine had squashed down vertically on the pontoon as the propeller had kicked a hole in the pontoon directly beneath it. In the second crash the airplane came down with its two occupants in a relatively steep attitude, spinning rather fast. Before one of the pilots died, in a more or less delirious state, he stated that something went wrong with the controls and the airplane could not be brought out of the spin.

I was employed by the manufacturer of the airplane at that time as sales manager and feeling that first-hand knowledge of what was going on was desirable, decided to carry out certain tests personally to determine whether the airplane really had bad spinning-characteristices and, if so, what changes were necessary. An airplane of the same general type was lent by the Navy to carry out these tests and the first flight consisted of analyzing the characteristics of the ship in various maneuvers under the lightest loading-condition; that is, without any passengers or military load and only a small quantity of gas. I found that in a fast barrel roll when an attempt was made to execute only a single roll, it was impossible to do so. When the airplane had reached the stall point it had rolled almost beyond the upside-down position, which was too late, with the existing effectiveness of the control surfaces, to retard the rotation and bring the airplane out with the completion of only one full roll; that is, bringing the airplane out right side up and perfectly level, without any yawing, rolling or dipping. Invariably, if the stick and rudder were held until the airplane actually stalled and then the controls were reversed, the airplane would pass through a single full roll with the nose dropping, yawing and rolling, and in many instances would continue on over in an almost inverted position. After pulling the stick and giving full rudder if they were taken off before the wing actually stalled, a single roll could be completed but it would be nothing more than a sloppy combination aileron and rudder maneuver.

TEMPLE N. JOYCE

Barrel-Roll Tests

I felt that before doing any spinning tests I would like to have the airplane able to execute fast barrel rolls satisfactorily and my impression at that time was that all that was necessary was to add a large enough elevator to stall the wing completely and quickly with possibly a slight addition of rudder area. With this idea in mind a new set of control surfaces was made with approximately 50-per cent increase in the elevator area and about 20-per cent increase in the rudder. In the first flight I found that the rolling condition of the airplane was but partly improved and in all instances, upon executing one complete roll, it came out rolling, yawing and pitching regardless of the opposite-control position. The elevators, however, were very effective, and I felt that if a spin were taken cautiously and under light-loading-conditions, attempting a few would be safe.

Consequently with a safe altitude the airplane was spun successively a number of times to the right and left for 1000 ft., a number of times to the right and left for 2000 ft., one turn to the right for 3000 ft. and while waiting for a 3000-ft. spin to develop to the left, at 2500 ft. a sudden fluttering of the stick with a following reversal of stick forces was noticed; that is, the stick tended to stay aft and excessively high forces were required to push it forward with a very slow rate

of recovery. At the first warning of this reversal of stick forces I immediately attempted to recover, fearing to let it stay in for any length of time because I had recognized the condition that was apparently the cause of the death of four naval men. The attitude of the fuselage apparently did not change and subsequently the same afternoon the plane was allowed to stay in for 500 ft. after the reversal of stick forces with no further change noted in the angular attitude of the fuselage. Another spin was executed to the right for 4000 ft. with no change in the attitude of the airplane or the controls. The spin was perfectly normal with no reversals of stick forces. Several spins were executed to the left for 4000 ft. with the airplane staying in the reversal of stick-force attitude for about 2500 ft. Recovery was much prolonged but there was no tendency on the part of the fuselage to flatten out.

Effect of Placing Balance on Flippers

To reduce the stick forces a balance was placed on the flippers, increasing the total area 2.2 sq. ft., and on the first flight I decided to spin to the right for approximately 2000 ft. before attempting any left-hand spins. The airplane was stalled in the usual manner and I sat in the cockpit patiently watching the altimeter, expecting to spin to the right for 2000 ft. and then recover. At 600 ft. a sudden flutter of the stick occurred and it came back much to my surprise, and I recovered as fast as the inertia and aerodynamic forces would allow me.

The suddenness of this change in the characteristics of the ship were so surprising that I immediately came down and landed to discuss the situation with ground observers. Apparently only 2.2 sq. ft. additional flipper area was required to throw the airplane from a condition where no delayed recovery or reversal of stick forces occurred when spinning to the right and only developing after 2500 ft. of prolonged spinning to the left to reversal of stick forces and delayed recovery to the right at 600 ft. In subsequent spins, all of which were done with exactly the same loading-conditions and with the center of gravity about 24 per cent, the airplane was made to spin, or shall I say I was made to spin with the airplane, in a perfectly flat attitude, with the stick forces very high and a much delayed recovery. The airplane in this attitude rotated rather rapidly with a vicious whispering sound in the wires which indicated a relatively low velocity and the wings banked to the side of rotation. A centrifugal reaction on the pilot to the rearward and to the inside of a spin developed which was so strong as often to require the use of the left hand to get the body forward enough to be able to give full-forward stick-movement. In many instances I was compelled to do certain spins a second time, particularly when attempting to make a mental record of what was happening to the rudder. I would suddenly realize that the airplane was not recovering as fast as in previous spins and then noticed that centrifugal force was pushing my body so violently against the rear of the seat that even though I had my arm forward at full length an additional body-movement was still necessary to get the stick to its furthermost forward position.

Various types of rudder, fin, stabilizer and flipper were used in subsequent tests with and without pontoons with varying degrees of success in making the spin more controllable. On one occasion, while spinning with seaplane gear and no military load and a small quantity of gas, I executed several flat spins that started with two or three turns of a normal spin and then gradually an oscillation was set up which increased in amplitude. Finally on one of the up swings of the nose the airplane got into a stable flat attitude to recover from which I had to use full gun in several instances. Apparently any airplane that spins with an uneven motion is bordering very close to the delayed-recovery condition and a slight change in the location of the center of gravity might make it a dangerous airplane.

With the same seaplane and under exactly the same loading-conditions and the same tail-surfaces, on one occasion the airplane was stalled in a very acute attitude and as the nose fell a very high rate of rotation and rapid descent immediately developed. The nose was almost vertical, accompanied by a reversal of stick forces, and before I was able to recover, 4000 ft. of altitude had been lost. I immediately landed and looked the airplane over for changes in alignment. Finding none, I went up in an attempt to duplicate the spin, but much to my surprise, I was unable to do so. I stalled the airplane while flying horizontally at 35, 40, 45, 50 and up to 55 knots, pulled the stick all the way back and kicked the rudder, kicked the stick and pulled the rudder, stalled the airplane in a steep climb with power partially on and off but apparently was unable to duplicate the same unusual spin.

Manner in Which an Airplane Enters Spin Is Important

From these various experiences I am convinced that what appears to be a normal-spinning airplane might, under certain conditions, be made to spin abnormally and bring about a delayed-recovery condition. Apparently the manner in which a spin is entered has considerable to do with its later characteristics and in the recent Bristol fighter spinning tests, the angle of attack of an airplane with exactly the same control-positions varied from 29 to 53 deg. I have had experiences under three conditions where an airplane could be spun either normally or abnormally, depending upon the manner in which the spin was entered. I believe that an airplane which is pushed into a spin while it has relatively high forward velocity can, by kicking the rudder, be translated into a rotating motion, thereby initially giving the masses or inertia forces an opportunity to take charge will, if the spin has any tendencies toward or borders on the delayed-recovery type, execute an abnormal spin from which recovery will be relatively difficult.

My experience with the 18-m. Nieuport has thoroughly convinced me that the students who crashed in the spiral class of that airplane apparently added too much rudder while the ship was actually above its minimum flying-speed and stalled the airplane afterward by pulling back on the stick and putting the ship into an abnormal spin from which they were unable to recover in the light of their inexperience. I have seen many JN4s spinning with a pronounced oscillating motion and I believe that under certain loading-conditions or entrance conditions, delayed-recovery spins were possible in Jennies and were responsible for many of our crashes in which our experienced friends were supposed to have been killed by students freezing on the controls. Every pilot, particularly students, should

know what to expect when he gets a reversal of stick forces and how absolutely essential immediate recovery is and not allow this condition to be prolonged.

Change in Spin Nomenclature Suggested

Furthermore, the use of the expression "flat spin" should be discontinued because it is misleading. An airplane may have reversal of stick forces and delayed recovery, as I pointed out previously, with the attitude of the fuselage either flat or vertical. The question of the explanation of this phenomenon will not be discussed here but will be left to the more technical discussions by some of the other contributors to this symposium.

Some differentiation should be made between stable autorotation as applied to a wing cellule and autorotation as applied to a complete airplane, taking into account the action of the controls and also that rotation of an airplane which may be absolutely independent of any control movement once the spin has developed. A flat spin, as long as it continues flat, is stable; likewise a normal spin, as long as it continues normal, is stable. We may say that one airplane is a stable-spinning airplane, and another type of airplane is also a stable-spinning airplane, yet actually one will break the pilot's neck and the other will not. The Curtiss Hawk is a perfectly normal-spinning airplane and is stable. The Vought-Corsair is also stable; so much so that we have a hard time getting it out of a spin. In this connection the nomenclature should be revised to differentiate between stable and unstable spinning airplanes. Apparently with the high wing-loadings in use today in relation to mass distribution and clean lines, we are getting into various types of spin different in their cause and effect and needing further clarification as to terminology. Before we can discuss scientifically what is going on in spins I think the National Advisory Committee for Aeronautics ought to develop terminology for these various types of spin and not classify them all under one broad heading. The easiest way to solve these problems is to have them correctly defined in the beginning and we are some distance from that point today.

The Cause and Prevention of Spinning

By Garland Powell Peed, Jr.[1]

WHILE the terms normal and flat are generally applied to spins, the author believes that controlled and uncontrolled would be better designations. The former is accompanied by righting forces and normal pressure-distribution on the control forces; the flat spin, by reverse forces of varying magnitude that usually are high. All airplanes will revert to normal flight easier from the inverted flat spin, which is attributed to the fact that the pilot can more easily apply full opposite elevator in this position rather than to the characteristics of the airplane. If full control is applied and held, almost any airplane built will come out of a straight flat spin, but few pilots will do this because of the work involved and also because the psychology and experience of inverted flight are lacking.

Essentially a spin is a stalled spiral and as the efficiency of an airplane increases, the spiral becomes flatter until the flat or uncontrolled spin is reached. How the airplane makes its initial turn is the most important point in discussing spins. The spin is not an extremely important part of aeronautical engineering other than to be able to build an airplane that does not spin uncontrollably. Building non-stalling airplanes is the really important task.

Methods of preventing flat spins are discussed at considerable length with the aid of mathematical formulas and the conclusion is reached that an unfavorable progression of moments is not in itself sufficient to cause a spin although the moments are a very large factor in giving the airplane its initial flat turn. Location of the center of gravity exerts very little effect on the spinning characteristics of an airplane.

The author concludes the paper with an account of the methods used to eliminate spinning tendencies from the Eagle Rock Bullet. The tests of this airplane led to the conclusion that to obtain true non-spinning characteristics in a low-wing monoplane the load should be high and toward the rear, which is exactly the opposite of what has generally been thought to be the case. In this airplane, which stalled and came down practically straight at the rate of approximately 11¼ m.p.h., the center of gravity was located 2 in. above the highest point of the wing and the acceleration was as high as 3 *g*.

IN any discussion of spinning two phenomena are invariably brought up, the normal and the so-called flat spin. Controlled and uncontrolled spinning would be far more appropriate terminology, as the attitude of the airplane has little to do with its spinning qualities. A seemingly normal spin may be flat or an apparently flat spin fully controllable, however this terminology is accepted and understood. The difference between these two types of spin is sharp and distinct. The controlled spin is accompanied by righting forces and normal pressure-distribution on the control forces; the flat spin, by reverse forces of varying magnitude, although usually rather high. Very probably a halfway point exists, but none has ever been reported and is very likely not to be, as such a state of spinning would so readily fall into one class or the other that any shift in weight or area distribution, no matter how small, would be sufficient to push the airplane over. The spinning of various ships in the past has been a case in point, wherein the airplane is in a flat spin and as the pilot stands up to jump, rights itself, but reverts to the flat spin when the pilot sits down again.

All flat spins are not uncontrollable and in extremely few should it become necessary for the pilot to leave

[1] Aeronautical engineer and consultant, Hotel Plaza, New York City.

the ship. The inverted spin of the PT1 Army training airplane is an uncontrolled or flat spin, yet the ship is very controllable and easily reverted to straight flight whereas the P1B, Curtiss Hawk, in the same position is hard to revert to normal flight and is almost uncontrollable. However, all ships will revert to normal flight easier from the inverted flat spin. This is not due to any characteristics of the ships but to the fact that it is easier for the pilot to apply full opposite elevator in this position. When in a straight flat spin the stick is pushed all the way forward to counteract the tendency, most pilots do not make use of all the movement possible but go only so far. Almost any ship built will come out of the spin if full control is applied and held there, but very few pilots will do this. It is extremely hard work for one thing and the psychology and experience of inverted flight are missing for another, and full forward stick is a control movement used only in inverted flight. The pilots who will apply full forward stick in any maneuver are few and far between. Even I, though I fully know the necessity for this and have experienced the maneuver time and time again, catch myself at times stopping short of full control, and invariably when full control is applied the airplane straightens out.

What Is and What Causes a Spin

A spin is in all essentials a stalled spiral, and the more efficient the airplane the flatter will be that spiral until the flat or uncontrolled spin is reached. An inefficient airplane does not flat-spin unless of freak design, whereas the modern efficient airplanes are showing that tendency more and more. Some engineers are using stops on the controls to prevent spinning, but that is a rather poor cure. An airplane factory that is producing new and more modern airplanes all the time should have had one or more ships that have performed flat spins, and any factory that has never experienced this trouble is so lucky as to raise suspicion as to whether it is really producing efficient airplanes. True, this knowledge of how to avoid this spinning is becoming far more widespread throughout the industry, but I doubt if any factory that is doing experimental work has missed it. Producing an uncontrolled spinning ship is no disgrace to any factory, rather it is a sign that its product is becoming more efficient. Since writing this paper originally, I have had an opportunity to visit many of the larger factories, and almost invariably the flat spin was a source of worry on some particular model that was being produced or had been built.

In the discussion of the spin the most important point is how the ship does its initial turn. If the causes for the initial turn and start of the spin are known, showing why the ship continues to spin is very simple for this is merely a further operation of the first causes. Newspapers, fiction writers and other romanticists to the contrary, *no airplane will, of its own accord, fall into a spin from normal or stalled flight.* One of the laws of motion is that a body following a curved path must have constant accelerations toward the center of the curve. So that for an airplane to spin, controlled or uncontrolled, some force must rotate the ship, and this or a similar force must act upon the airplane to cause the initial turn and the continued turning.

Of the numbers of accidents every year in which the ship is reported as "spinning-in" possibly not more than one or two in a hundred are true spins. I have not heard of more than four or five authentic cases in seven years and those only in testing. A true spin takes from 200 to 800 ft. to develop and nearly all of the "spinning-in" accidents occur from altitudes of 10 to 200 ft. They are not spinning accidents at all but stalling accidents.

Actually, the spin is not an extremely important part of aeronautic engineering other than to be able to build a ship that does not spin uncontrollably. We may build every ship non-spinning in five years, but the "spinning-in" accidents will still continue. The really important job is to build non-stalling airplanes. The new Alexander Bullet will not spin, for it is built so that, as spinning starts, corrective forces are set up and it stops. However, the ship must start to spin before it can correct itself and, to be able to start at all, it must be fully stalled. As long as any airplane can be stalled, it can be stalled close to the ground and can crash. A spin, then, must be started at some altitude over 500 ft. and must be forcibly continued. This is an unnatural maneuver for the average airplane, and if the ship is left alone, it will recover itself. Altitude is the prime consideration in spinning and training is the only thing that can really prevent accidents.

GARLAND P. PEED, JR.

The spin is a form of stalled flight and belongs under that heading. What and why is a spin is of value to us, inasmuch as it clears up some of the problems of stalled flight. Mysteries are exciting and interesting, as witness the rise of the detective story, and spinning has been a mystery and so interesting but not as important as has been believed.

Preventing Spins

The solution of the flat or uncontrolled spin is the present and future problem. I am not treating of the normal spin in this paper and hereinafter a spin means a flat spin, unless otherwise stated. In 1924, I was working in the engineering offices of the Boeing Airplane Co. at Seattle. The company had just produced a training airplane for the Navy known, with different engines, as the NB1 and the NB2. This ship was having trouble in its spinning and was the first airplane that I have any knowledge of to produce the flat spin. It was an unstaggered, square biplane of good aspect ratio and rather efficient. In a discussion, one day, of this ship, I advanced the theory that it should be staggered. This, in the light of present knowledge, would have cured the trouble; however, I had no definite knowledge to back why I thought this would be the solution and it was five years later before I could give reasons.

In normal flight an airplane is pulled along by the thrust of the propeller, and its flight path is a resultant of this thrust and air force on an inclined plane. As soon as the engine is shut off, the thrust is removed

and the resulting flight path is determined by gravity and the gliding efficiency of the airplane, which is roughly determinable by the L/D ratio. However, instead of acting forward, as does the engine thrust. gravity acts downward; and in spinning the angle of attack is very high. Therefore, using V_r as the resultant velocity, C_n as the lift coefficient, W as weight and S as the surface, $V_r = \sqrt{(W/C_n\ S)}$ neglecting parasite resistance and other factors that for any one ship are constant.

Then as W/S remains constant for each particular ship, V_r varies as $\sqrt{(1/C_n)}$. From this we see that the lower the value of C_n, the higher the value of V_r must be to equalize the weight of the airplane. Then, since the angle of attack varies so greatly along the span, the outer wing-tip must travel much faster to carry its share of the weight. This is given by the ratio

$$\frac{V_{r\ inner\ tip}}{V_{r\ outer\ tip}} = \sqrt{\frac{V_y^2 + [2\pi\ (r + 1/2\ b \cos\psi \cos\mu)]^2}{V_y^2 + [2\pi\ (r - 1/2\ b \cos\psi \cos\mu)]^2}} \qquad (1)$$

where

b = Span
μ = Angle of pitch
ψ = Angle of yaw
r = Radius of spin to center of gravity
V_y = Sinking distance per turn

But to be in spinning equilibrium the V_y of the two tips must be equal. Then as

$$\frac{V_y}{2\pi\ [r + 1/2\ b \cos\psi \cos\mu]} = \tan\phi$$

where φ equals angle of the flight path of the outer tip to the horizon. Then $2\pi[r + 1/2\ b \cos\psi \cos\mu] \tan\varphi$ *for* the outer tip most remain equal to V_y. Then the V_r ratio becomes

$$\frac{V_{r\ outer\ tip}}{V_{r\ inner\ tip}} = \frac{[r + 1/2\ (b \cos\psi \cos\mu]\sqrt{(\tan^2\phi + 1)}}{[r - 1/2\ (b \cos\psi \cos\mu]\sqrt{(\tan^2\phi_1 + 1)}} \qquad (2)$$

where φ_1 is angle of flight path of the inner tip to the horizon. Then the greater r becomes, the less will be the proportionate difference between $V_{r\ outer\ tip}$ and $V_{r\ inner\ tip}$ So that the larger we can make the radius of the spin, the less will be the forces that must be overcome to revert this spin to normal flight. Here, however, another condition enters. To flatten the angle of pitch, the moments above the center of gravity on the Y axis must be built up and a large progression along the Z axis given. This tends to flatten the airplane's path and to decrease the variation between the angle of attack of the tips, and therefore decreases the V_r ratio. Now if, at this time, the C_n value on the inner wing decreases for any reason this wing will tend to drop until the increase in speed, resulting from this falling-off, balances the decreased lift; the increased speed, however, has resulted in increased progression of moments to such an extent that the center of pressure of the wing has moved from beneath the center line of the ship to some point on the outer wing. The progressions balance the unbalanced moment due to the pressure off center and the ship is in spinning equilibrium.

Demarcation Between Biplane and Monoplane

The biplane shows a decrease in lift at the higher angles, so that the conditions noted hold for this type of wing arrangement. Then, in the biplane, the progression of moments must be favorable and a forward center of gravity must be designed into this type to prevent flat spinning. Seemingly, no standard biplane is built today which cannot be made to flat-spin under adverse loading-conditions. However, this does not prevent normal spinning, and to prevent spinning may be impossible in a biplane.

For the monoplane, a steady increase in C_n at the higher angles is found. From this, then, we can expect to get conditions opposite to that of the biplane, especially in the cantilever low-wing type, where the progression of all moments is unfavorable. Here the inner wing is doing most of the lifting, and the moments are augmenting the unbalanced forces set up. Then the airplane tends to rotate away from the spin's axis and the resultant is a partial turn, first to one side, then to the other, resembling in all particulars a falling leaf.

This shows a distinct line of demarcation between the biplane and the monoplane, although each case will have to be investigated individually. The high-wing monoplane may be governed by biplane characteristics, since the progression of moments is similar. A general rule, however, is that the more efficient the ship, the greater the possibilities of flat spinning.

The problem of flat spinning is primarily one of advanced design. The earlier types of airplane were almost totally lacking in the requirements necessary for this maneuver. These conditions will probably be encountered more and more in the future, for the greater the advance in engineering, the more the necessary requirements are fulfilled.

Progression of Moments and Spinning

I am not trying to minimize the importance of the progression of moments, but merely stating that the existence of an unfavorable progression is not in itself sufficient to cause the spin. The moments are a very large factor in giving the airplane its initial flat turn in many cases. Nevertheless, in instances the flat spin was present from the first turn, and whereas the moment progression undoubtedly helped to cause this, it is not by any means the controlling factor. Because this has been gone into very fully in other studies of the subject, I will not attempt to give a detailed explanation here other than to state that an unfavorable progression coupled with other unfavorable qualities will, in nearly all cases, result in a flat spin.

Center-of-gravity location has very little effect upon the spinning characteristics. Certain biplanes will flat spin with a forward center of gravity, but are perfectly normal when rigged properly with the center of gravity farther aft. However, the qualities necessary for this maneuver were present before the center of gravity was changed. That progression must be favorable for spinning to obtain the very tight flat spin, although even with a slightly unfavorable progression a true spin of this type can be obtained. I have in mind a biplane at present on the market, which normally has extremely easy handling qualities with absolutely no trace of characteristics that I have been discussing. However, by poor rigging, cutting down the stagger and adding "wash-in" to the tips, the plane is susceptible to true flat spins. The center of gravity, if changed at all, is moved forward, tending toward normal spinning. An investigation of the C_n values of this airplane, however, showed an unusually low value for the ship with the lessened stagger; on this factor can be laid the blame for the uncontrolled spinning experienced.

Equation 2 did not take the factor of time or the lift of parts of the ship other than the wing into consideration. Substituting M for $1/2\ b \cos \varphi \cos \mu$ we get

$$\tan \phi / \tan \phi_1 = (r - M) / (r + M)$$

and

$$2\pi \tan \phi_1 (r - M) = 2\pi \tan \phi (r + M) = V_y$$

but

$$\Sigma V^2 CS = W - L_1$$

where

C = Coefficient of lift at any point along the wing
L_1 = Lift of other parts of the ship
S = Area affected by C and V
V = Velocity of the point on the wing having a lift coefficient of C
W = Weight of the airplane

Then

$$V_{max} = V_{ro} N$$

where

N = Turns per second
V_{ro} = Distance traveled per turn by the outer tip

$$V_{ro} = 2\pi (r + M) \vee (\tan^2 \phi + 1)$$

Then

$$V_{max} = 2N\pi (r + M) \vee (\tan^2 \phi + 1)$$

and

$$V_{min} = 2N\pi (r - M) \vee (\tan^2 \phi_1 + 1)$$

V_{max} and V_{min} are in feet per second and the only variation is in the angle of attack.

Lift of Rotating Surfaces

The lift of rotating surfaces is as yet an unsettled question. Some of Dr. Max Munk's calculations and experiments tend to show that a rotating area has a considerably higher lift than the same surface in straight flight. Certainly the Autogiro has a much higher loading per square foot of supporting area than any of our normal airplanes. An airplane in a spin

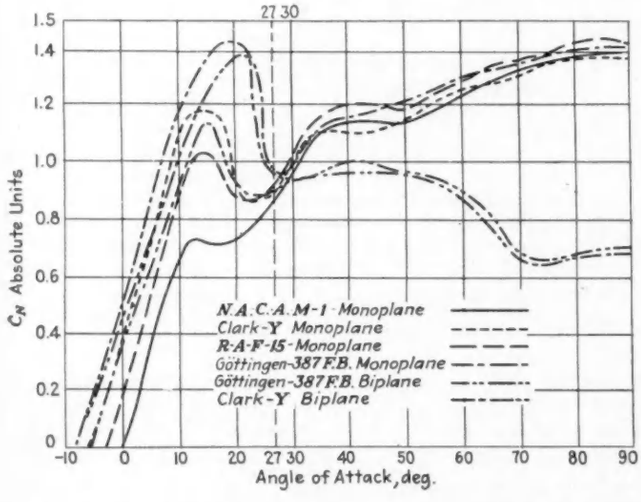


FIG. 1—C_n VALUES FOR FOUR MONOPLANE AND TWO BIPLANE WING-SECTIONS

acts as one blade of an Autogiro in a vertical descent. This uncertainty of loading capacity makes for uncertainty of calculation, although the lift of the Autogiro is probably due to the high speed of rotation. If this is the case, then the calculation of lift follows the charted values and is comparatively simple. However, since so few experimental or test data upon this are available, nothing is definitely certain at present.

At high angles of attack the lift builds up remarkably. In fully stalled flight, with four people, the Alexander Bullet showed a vertical rate of descent of between 900 and 1000 ft. per min., which corresponds to about 11 m.p.h. This, of course, does not take into consideration the forward velocity, but as the ship was fully stalled this was certainly not high. In fact the airplane was landed in this position from 300 ft. and showed no ill effects, although the landing gear was standard size and not the long travel as used on the Guggenheim Safety Ships.

According to Fig. 1 the lift increases as the angle becomes nearer 85 deg. except in a biplane, in which a marked decrease occurs at the higher angles. From this the theory of the monoplane and that of the multiplane would seem to be widely varying. The most efficient monoplane insofar as regards non-spinning and non-stalling characteristics is one in which the lift coefficient increases steadily to reach a maximum at 80 to 85 deg. angle of attack. This ship would not tend to stall and fall off as does the conventional type.

Lift of Tail Surfaces

However, in every discussion of spinning the lift of the tail surfaces must be taken into account. At angles of attack above 30 deg. the horizontal surfaces will carry as much load per square foot as the wings, the only major variation being due to aspect ratio. This lift is not affected as much as might be expected by forcing the elevators down, especially at angles above 70 deg., though the corrective effort is generally sufficient if they are forced to the extreme limit of their travel. A rearward progression of moments in a spin merely acts as a shifting of the load rearward, which loads up the tail surfaces until they have attained an angle of attack and velocity sufficient to support the load, but this does not cause the spin. That is due to the inability of the inner wing to carry its share of the load. I have explained this far more fully in an earlier article[2].

In any case, the sum of the total lifts of various parts of the plane must balance its weight. However, the coefficients vary greatly and certain parts of the ship are loaded far heavier than others. The speed of various parts also varies, although the V_y or vertical sinking speed is constant; in fact, in any one ship, it and the radius of the spin are the only constants.

In a paper of this length, taking into account the various factors that enter into a spin is impossible. That could not be done in anything smaller than a book and perhaps not in that. For that reason much of this paper is sketchy and indefinite. I have attempted to give the general idea more than specific examples. Personally, I have not the equipment necessary to carry on the research in solving these questions in my present position, and so I have tried to give what I have found so that engineers better equipped than I can follow them through to their conclusions. Personally, as I have stated earlier in this paper, I do not believe the spin is nearly as important as it has appeared. An accident caused by a true spin is almost an impossibility. The average commercial ship takes 250 to 400 ft. to begin spinning and almost all of the so-called spinning accidents occur at altitudes considerably less than that. The solution to these accidents is non-stalling airplanes. This has not been done so far.

[2] See *Aero Digest*, June, 1930, p. 77 and July, 1930, p. 74.

Although many attachments for preventing stalls have been put on airplanes, the best of these merely postpones the stall to a slightly higher angle of attack and is worse than the normal plane to recover. The spin is not eliminated. If the stall could be eliminated or controlled, these accidents would stop occurring; in fact, then to even spin would not be necessary.

The Eagle Rock Bullet

In the preliminary investigation of the Eagle Rock Bullet we used every known method of straightening a ship out of a spin. Everything we did seemed to make

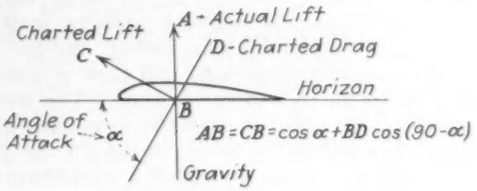


FIG. 2—DIAGRAM SHOWING ORIGINAL METHOD USED BY THE AUTHOR IN ATTACKING THE SPINNING PROBLEM

it spin worse. The farther forward the center of gravity was put the worse the spin became. So we discarded everything we knew about spinning and started from scratch. The original calculations were all done on paper with no test work. In fact, so many factors were unknown that we tried to use merely a few. I think we used eight unknowns to get our answer.

The ship was built and did not prove as satisfactory as we expected, so a second ship was built. The original ship would not spin at all, at least not anything that we would call a spin. It would barrel-roll first to the right and then to the left. It would make a half-roll to the right with controls in the full-left position for the spin. It would make a half-roll to the left and a half-roll to the right. It would half-roll to the right three times as fast as it half-rolled to the left. The acceleration was so high that the boxes of shot were collapsed and driven right down in the floor. They were supposed to have a factor of safety of 8. The deflection on the wing tips in one maneuver was 6 in.

The ship would go over on its back, then straighten out once and turn upside down. It varied that performance considerably. I do not think it did the same thing twice. It seemed to start from any angle it got into and then do something wild and then straighten out and decide to do something else the next time. That was not very satisfactory, so we took the ship back to the factory and tore it to pieces, trying to find out what was wrong. We built another ship that was identical in plane, although we raised the center of gravity 2 in. so that it was 2 in. above the highest point of the wing tips. The ship was tested at low angles, at low loadings where the center of gravity was very far forward, and would come down seemingly in a normal spiraling dive, but the air speed went up to very high values. The controls were all the way back, the full rudder was applied and yet the ship would run away from a pursuit airplane on a dive. We did not call it a spin, but as no very high force was involved we thought that we would get by. As we shifted our center of gravity farther to the rear, the loads began to get lighter and the ship began to act more reasonable. Finally, after getting the equivalent of two passengers in the rear seats with only one pilot in front, the ship would perform a falling leaf. It was not a spin, but a true falling leaf. The controls remained in one position. With the rudder turned fully to the left and the flippers and left aileron full up, the ship would make a true falling leaf and continue that. It would fall off and return. Once in a while it would get enough speed to turn itself over. It would dive 500 ft. or so and straighten out and make more falling leaves. That was its performance in tests from any position, putting it into a spin from inverted flight with the engine running at full speed or stalling it into a spin by using full rudder and flat stall. We tried every way of putting the airplane in a spin and the result was the same after the first 500 ft.

As we got the final load in the rear, the ship would stall and come straight down with no measurable deflection at all, just as though the pilot were trying to make a straight stalled flight. The rate of descent was about 1000 ft. per min. or about 11¼ m.p.h., and the forward rate of speed was about 35 m.p.h. That particular ship was taken to the City of Washington and passed the Department of Commerce test after a lengthy argument.

Conclusions Contrary to Everything Taught

The conclusions we reached from this were that, for the low-wing monoplane, but not necessarily for the biplane or for the high-wing monoplane, to get true non-spinning characteristics the load should be high and to the rear, which is exactly the reverse of every-

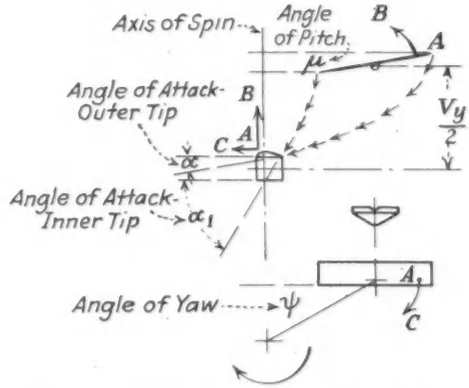


FIG. 3—DIAGRAM SHOWING THE ACTUAL CAUSE OF FLAT SPINS

thing we have been taught. However, when we had a center-of-gravity position of 28 per cent, the gyrations were at their worst and the accelerations were highest. When we shifted the center of gravity back to 36 per cent no gyration occurred and the ship came straight down in stalled flight.

The center of gravity was 2 in. above the highest point of the wing. In the original ship we had accelerations as high as 3 *g*. We had pressure indicators on the tail which showed the tail was doing far more lifting than we expected.

Our calculations on the low-wing monoplane eventually showed that we should have the center of gravity considerably to the rear with the lifting tail and we would get a ship that would not spin. Whether the Department of Commerce would allow us to put it

through or not was the reason we did not build our ship that way. At present with the ship fully loaded the center of gravity goes to the rear of the center of pressure.

In the original attack on this spin, we took our angle as zero at the ground. The spin is caused by gravity and as the thrust is missing, we took the actual lift or coefficient of attack normal to the wing surface as our unit. We calculated on that basis that the lift was opposite to gravity and not necessarily perpendicular to the direction of wind flow. The lift then was the value *AB* (Fig. 2) and not *CB* as has been used before. That was where we got our first clue.

Fig. 3 shows what we determined was the actual cause. This is the primary rotation of the ship in the flat spin. A secondary rotation occurs in certain ships in which this circle is rotating about a larger circle in certain flat spins. It means that ship is doing a spin around itself in a form of descending spiral and that spiral itself is running around a larger spiral. The radius has purposely been made larger for clarity.

Fig. 1 shows the conditions, with a coefficient normal to the chord line of the wing. This is calculated for NACA-M-1 section of a Göttingen 387. Considerable difference is found in the lift of those two sections below 27 to 30 deg. Above that point, so far as the monoplane is concerned, there is practically no difference. The little there is could be attributed to different testing conditions. The lower pair of lines are the characteristics of two biplane-wing sections.

To whip the so-called flat spin we decided that if we could, in the spin, get our wing with a high angle of attack along the wing section so that our inner wing-tip was at 85 deg. and the outer wing-tip at 27 deg., we would increase the lift of the wing on the inside of the spin. Up to that time we had had our outer wing-tip at about 4 deg. and our inner wing-tip at about 35 deg. Thus the summation of lift on the outer tip was greater than that of the inner tip, so as soon as the ship started rotating, the inner wing naturally fell faster, owing to the fact that it did not have as much lift. When we built the ship so the distribution of angle was as first mentioned, then the inner wing was giving the most lift. As soon as the rotation started, the outer wing-tip dropped and the inner wing-tip lifted. That was calculated experimentally by mathematics at first and then was applied to the actual construction of a ship.

These findings are altogether contrary to what has been taught us, but they worked. Doing this to the biplane does not seem to help. The higher the angle of attack the worse the spin gets, because the curve is gradually descending. But it was the monoplane in which we were interested, we were not interested in the biplane at all; our biplanes would spin normally unless rigged improperly.

We built our monoplanes so our progression of moments was high enough to flatten the spin to such an extent that as I said before the ship fell over backward and would not spin at all.

Spinning Experiments

By Paul E. Hovgard[1]

AN effort to find an easy cure-all for flat spins was responsible for the tests described in the paper. Among the expedients resorted to were moving the ballast from the center of gravity to various locations and varying the position of the center of gravity from 40 to 26 per cent of the mean chord.

With the weights in the center section and the bottom of the pontoon, the transition from a normal to a flat spin was hardly perceptible and recovery from a long spin was made in 1½ turns where 5 were formerly required. Moving the center of gravity an additional 2 per cent of the mean chord necessitated an increase in the up-elevator throw to start a spin but the airplane could not be spun without going into a flat spin.

Effects of decallage and washout on the stability of the airplane in a roll are commented upon as are also changes in horizontal tail and fin areas, raising the horizontal surface and using a positive dihedral in the horizontal tail. According to the author the relation between the ability of an airplane to barrel roll and to spin is close and those airplanes that are the most difficult to barrel roll invariably seem to have the greatest difficulty in recovering from spins.

THE spinning tests conducted at the Keystone plant were started in an effort to find an easy cure-all for flat spins in the same manner that the alchemists of old tried vainly to find the philosopher's stone that would perform the transmutation of elements. Only after all the prevalent theories on causes of flat spins were tested was a really intelligent investigation started.

The force behind the rotation of the airplane is primarily its weight; the greater the weight, then the faster should be the rate of rotation. We found that we could perform prolonged spins without going into a flat spin by omitting enough of the useful load of the airplane. Ballast was then added at the center of gravity to increase the weight without appreciably changing the moment of inertia about any axis. As the weight was increased the rate of rotation was increased until it reached its critical point and went over into a flat spin.

Effect of Shifting Ballast and Center of Gravity

The ballast was moved from this central location to various points in the tail and fuselage, the engine mounting and the center section, the wing tips and the bottom of the pontoon. Moving the ballast to the wing tips or to the engine mounting and tail made the spin more difficult to start. With ballast at the wing tips the number of turns for a normal spin before entering a flat spin was increased, while with ballast in the nose

[1] Aeronautical engineer, Keystone Aircraft Corp., Bristol, Pa.

and tail, the number of such turns decreased very markedly. The recovery from the flat spin in either case was practically the same. With the weights in the center section and the bottom of the pontoon, no difference in the entry to the spin was apparent and the transition from a normal to a flat spin was almost unnoticeable. Recovery from a long spin was made in 1½ turns whereas the recovery from spins in a previous condition required 5 turns.

The foregoing tests were all made with the same center-of-gravity location. Tests were made later on the center-of-gravity location without changing moments of inertia or static weights but by using varying degrees of sweepback. The center of gravity was moved in four stages from 40 to 26 per cent of the mean chord. In the most forward position entering a spin without first increasing the up-elevator throw was impossible. As the center of gravity was moved forward, the spins were harder to start but recovery from a long spin was unchanged. In one case by reducing the up-elevator throw a prolonged spin was made without going flat. The center of gravity was then moved 2 per cent of the mean chord. Increasing the up-elevator throw to start a spin was then necessary but the up-elevator could not be adjusted so that the airplane could be spun without going flat.

Decallage and Washout Effects on Stability

Some time ago B. V. Korvin-Kroukovsky[2] published results of some tests made on the effect of decallage and washout on the stability of an airplane in a roll. These two features were incorporated in the airplane and the results checked perfectly. The spin was possibly a little easier to start but could not be carried nearly so far. Until enough decallage and washout was incorporated, however, to eliminate the flat spin entirely, no difference in recovery from the flat spin was apparent. When carried far enough the rate of rotation increased as the control column was pulled to the rear. As the rate of rotation increased, the force required to hold the stick in the rear position also increased and when the stick was released, the airplane snapped out of the spin in about one-half turn.

In this connection the stability of the airplane in normal flight was really uncanny. Although the stick forces required with the original airplane were very low due to the balance of the surfaces, after rigging, decallage and washout, they were so high that the stick could not be moved to any extreme position when traveling above approximately 80 knots. Turns to almost a vertical bank can be made with rudder alone with very small amount of slipping or skidding and with a variation of air speed of not more than 10 m.p.h. Perfect snap rolls could have been made by a novice almost without thought. An airplane with these flying qualities was by no means a satisfactory training airplane and this method of attack had to be abandoned.

The most dependable modification to remedy spinning characteristics is an increase in area of the horizontal tail. This surface was increased by stages to approximately 80 per cent over its original area. After an increase of about 50 per cent, further increase was not effective. The increase of 50 per cent reduced the number of turns required for recovery from a flat spin from 5 to 3¼. One hundred per cent increase in fin area had very little effect on the recovery from flat spins, reducing the number of turns from 5¼ to 4¾. Raising the horizontal surface 32 in. above its normal position had no effect on the spinning characteristics.

A positive dihedral of 10 deg. in the horizontal tail reduced the number of turns required for recovery from 3¼ to 1¼. This idea may or may not appeal to the commercial purchaser but it does not seem to bother the Navy since some pilots are now being trained in airplanes that have dihedral in the horizontal surfaces.

Location of the Axis of Rotation

The theoretical studies of spins so far published invariably assume the axis of rotation of the airplane or wing cellule to be either through the center of gravity or intersecting the longitudinal axis and in the same plane as the vertical axis. Invariably, however, test pilots report a side force or a yaw in the spin which means either that the axis of rotation is to one side of the longitudinal axis or the axis of rotation is not in the same plane as the vertical axis, more probably the first. In a normal spin the axis of rotation actually or nearly intersects the longitudinal axis, but apparently when the rate of rotation has reached a certain point, the axis is not stable in this position. In some cases the airplane will oscillate a few times before it leaves that position and in other cases it leaves that position in a single movement. Using the terminology of longitudinal stability one may say that, in the first case, the axis of rotation is statically not dynamically stable on the longitudinal axis and in the latter case, statically unstable on the longitudinal axis. Theoretical calculations and the type of wind-tunnel tests so far made can determine the characteristics in a normal spin and keep the rate of rotation low enough so that it may not reach the point at which the position of the axis of rotation is unstable.

PAUL E. HOVGARD

Some account must be taken of the variation in spinning characteristics of two airplanes that are apparently identical. In testing a series of 15 new amphibians, according to all inspection reports exactly alike, a large difference in spinning characteristics would be found. Some of them could be spun apparently indefinitely and would still recover hands off, while others spun under the same condition require about 1½ or 2 turns for recovery with reversed controls. All of them apparently have very small reversal of stick forces, yet some of them can bring themselves over the hump and stop the spin while others cannot. These spins were made at less than full load and I do not recommend that they be repeated.

Of course, a close relation exists between the ability of an airplane to barrel roll and to spin. In some of these airplanes a barrel roll appears impossible while in others a fairly good barrel roll can be made without very much difficulty. Those that are the most difficult to barrel roll are invariably the ones that appear to have the most difficulty in recovering from the spins.

[2] See *Aviation*, July 18, 1927, p. 152.

Airplane Tail-Spins Analyzed

By Harry A. Sutton [1]

AFTER trouble in recovery from airplane spins had been experienced in foreign countries and in the United States, general conjectures were made regarding the probable reasons; but very little in the nature of systematic investigation was attempted until recently, and therefore no generally applicable principles had been determined, although numerous studies had been made in wind tunnels and it was recognized that the normal airfoil would rotate automatically under certain conditions. A few flight tests had indicated that the center-of-gravity location with respect to the resultant air-force vector on the lifting surfaces influenced the type of spin and the ease of return to a normal attitude.

Following a fatal accident at Dayton, Ohio, which occurred in an airplane that was considered a very desirable type and which had been in production for some time, an investigation of the spinning characteristics of this type of airplane was started. A wind-tunnel study was made but, although this provided valuable data, it was realized that dependence should be placed on flight tests to determine the effects of modifications suggested by the laboratory tests.

A systematic program of tests was started to determine, on two airplanes differing greatly in wing-cellule arrangement, the effects on spinning characteristics of varying, (*a*) the center-of-gravity location, (*b*) mass distribution, (*c*) control position and (*d*) engine power. The general characteristics of the first airplane tested are illustrated and the test procedure is stated, the effect of changing mass-distribution is mentioned and the results of the tests are described. Lateral mass-distribution is also commented upon, and a new airplane was designed which incorporated all of the information that was secured from the tests made.

After tests of this new model were made, the conclusion was reached that the rearward weight added behind the wings delays recovery from a spin. Factors that should be investigated to secure further improvement which will assure recovery from tail-spins include wing-cellule arrangement, balance location, mass distribution, vertical and horizontal tail-surface design, high-wing and low-wing monoplane arrangement and many other factors of presumably less importance, according to the author.

THE SERIOUS nature of difficulties which might be encountered in tail-spins was brought forcefully to the attention of the Materiel Division of the U. S. Army Air Corps in the Spring of 1926 when Lieut. E. H. Barksdale lost his life in attempting to determine the cause of difficult recovery from spins in a military airplane being flight tested at Dayton, Ohio. Trouble in recovery from spins had been encountered in several instances in foreign countries and one or two cases had occurred in the United States; but the problem was not considered as one generally applicable to all airplanes because, in most cases of previous trouble, the airplanes concerned possessed unusual design features which were thought to be mainly responsible for their abnormal behavior.

Prior to this, general conjectures had been made regarding probable reasons for difficult recovery from spins, but very little in the nature of systematic investigation had been attempted; consequently, no generally applicable principles had been determined. Numerous studies had been made in wind tunnels and it was recognized that the normal airfoil would rotate automatically under certain conditions; but the magnitude of the forces involved and, therefore, the ability of an airplane to recover a normal attitude by use of the controls, could not be determined readily by wind-tunnel tests. A few flight tests had indicated that the center-of-gravity location with respect to the resultant air-force vector on the lifting surfaces influenced the type of spin and the ease of return to a normal attitude.

The accident at Dayton, Ohio, occurred in an airplane which was considered a very desirable type and which had been in production for some time. Since it appeared improbable that any structural failure or other mechanical trouble had caused the accident, an investigation of the spinning characteristics of this type of airplane was started. Airplanes of this type had been in regular service-use for a considerable period without causing similar trouble; but, the tactical requirements of this type did not require spinning and, consequently, the airplane had not been spun often and then only for a turn or two. This was fortunate in view of the later discovery that spins, in many cases, often change decidedly if continued for several turns.

Wind-Tunnel Study Made

A theoretical and a wind-tunnel study of the particular problem confronting the Materiel Division was started at Dayton, while the manufacturer made an investigation of the effects of various modifications of the airplane. The wind-tunnel studies mainly confirmed previous results secured in similar investigations, and the practical value of results it was possible to secure by this method seemed small compared to the time and effort required. This became apparent as more thorough consideration was given to the mechanical and aerodynamic principles involved in a spin. It became necessary to make so many approximating assumptions in an attempt to reach conclusions that the probable error in results became very large, so that all studies of this nature were subject to considerable justifiable controversy and no conclusion could be supported without proof from actual demonstration in flight.

These conditions were anticipated from consideration that our fundamental aerodynamic theories are based on steady motion, small oscillations and other conditions which seldom occur in normal flight, and certainly not at all during the spin. It was thought, however, that some general tendencies or differences could be found between the results from wind-tunnels and the like, which might reasonably be expected to apply to full-scale airplanes and thus reduce the amount of necessary full-scale modification and testing.

Theoretical analysis of the motion of spinning under broad assumptions and consideration of the effects of mass of the airplane under the assumed conditions indi-

[1] Chief engineer, The Aviation Corp., New York City.

cated the possibility of particularly serious combinations of forces tending to maintain the airplane in a spin against the largest probable control effort which could be exerted to recover a normal flying attitude. The wind-tunnel studies[2] did provide valuable assistance; but it was realized that, largely because of the lack of sufficient exact knowledge of what happens in a spin, dependence should be placed on flight tests to determine the effects of various modifications suggested by the laboratory investigation.

The particular problem of conducting flight tests in such a manner that desirable modifications could be made while providing means for assuring recovery from all spins, thereby permitting the pilot to devote more thought to observation of the spin, was solved by the airplane manufacturer. Although not definitely known to apply in all cases, it had been found in previous investigations that, when the center of gravity was located very far forward of its normal position, recovery from spins was at least more certain than with the center of gravity in its normal location. For this reason the test airplane was fitted with droppable weights which would cause a movement of the center of gravity to the desired position when they were dropped if necessary during a spin. Flight tests were greatly facilitated by this arrangement, which proved successful and relieved the pilot of considerable worry.

HARRY A. SUTTON

Test Program Outlined

Following some preliminary tests of various modifications of control surfaces, none of which produced the desired results, a systematic program of tests was started to determine, on two airplanes differing greatly in wing-cellule arrangement, the effects on spinning characteristics of varying, (*a*) the center-of-gravity location, (*b*) mass distribution, (*c*) control position and (*d*) engine power.[3]

Facilities were not available for recording during flight all of the desired data, such as motion of the airplane, accelerations, control positions and control forces during the tests. A compromise between research study and practical testing was made by securing an accurately timed photographic record of spins from the ground and recording as much information as could be conveniently done from observation of the instruments during a spin. Spins were continued for several turns; generally at least 8 and, in many cases, 20 turns were made before starting recovery.

The general characteristics of the first airplane tested are shown in Fig. 1. Ballast tanks were placed in the fuselage and bomb racks were installed on each lower wing. The ballast, consisting of lead shot in the fuselage tanks and bombs loaded with shot on the bomb racks, was droppable in flight. A series of tests was made under different balance conditions without load on the bomb racks, beginning with the airplane light and balanced at about 19 per cent of the mean aero-dynamic chord. The weight of ballast was increased by small increments between flights with corresponding movement of the center of gravity to the rear until an unsatisfactory spinning condition was reached at a balance location of 38.9 per cent of the mean aero-dynamic chord.

Under the initial conditions the airplane responded quickly to control action during a spin; it spun regularly with its *X* axis inclined about 20 deg. to the vertical and at a rate of about 2 sec. per turn. The loss in altitude was between 200 and 250 ft. per turn during the spin, and recovery could be effected easily with about 600 ft. loss in altitude. With the balance at 38.9 per cent, the airplane spun very irregularly with its *X* axis inclined about 50 deg. to the vertical and at a rate of about 2.5 sec. per turn; recovery was slow with high control-forces and required about 1500 ft. of altitude with all controls completely reversed. These tests demonstrated the effect of the center-of-gravity location in this airplane for all practical purposes, since the balance was changed by varying ballast-loads located in approximately the same place as was the variable military load in the fuselage.

To determine the effect of lateral mass-distribution, additional tests were made. Beginning with the most rearward balance location which resulted in satisfactory spinning-characteristics without load on the bomb racks, tests were made with varying bomb loads until unsatisfactory spinning-characteristics were encountered for several balance locations. For a balance location of 35 per cent of the mean aerodynamic chord the limit was reached with

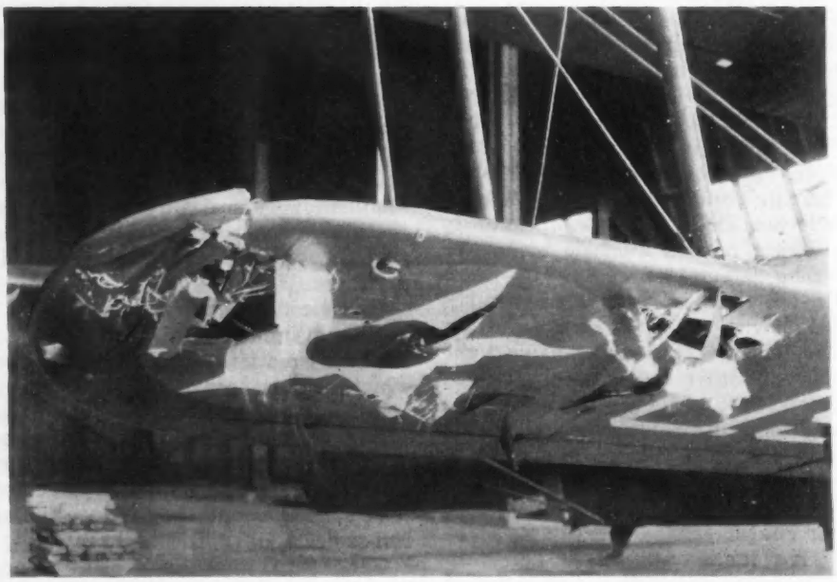


FIG. 2—DAMAGE TO RIGHT WING OF AN O2E-4 AIRPLANE, CAUSED BY DROPPING BOMBS WHILE IN A RIGHT-HAND SPIN

[2] Effect of Cellule Arrangement on the Rate of Autorotation Calculated by the "Strip" Method, by H. A. Sutton; see Air Corps Information Circular No. 609, Feb. 1, 1928.

[3] Airplane Spinning Characteristics, by H. A. Sutton; see Air Corps Information Circular No. 613, Feb. 15, 1928.

about 110 lb. of bomb load on each wing. This was increased to 225 lb. with the balance of 28 per cent of the mean aerodynamic chord before recovery from the spin became almost impossible. With the airplane balanced at 25 per cent of the mean aerodynamic chord, 275 lb. of bomb load was carried without excessive difficulty in recovery.

When a 300-lb. load was carried, it became necessary to release the bomb load to stop the spin. The bombs on the wing toward the center of the spin started through the wing, which was low, and damaged it considerably as shown in Fig. 2, thereby demonstrating the large centripetal forces which may be encountered when the lateral mass-distribution is great as in the case of multi-engined airplanes. In subsequent tests, ballast tanks holding lead shot were fixed on the wings.

Effect of Changing Mass-Distribution

The tests demonstrated the important effects of lateral mass-distribution independent of center-of-gravity location and led to tests to determine the effect of changing the mass distribution along the fuselage axis for several balance locations. A ballast tank was installed in the nose of the airplane and, with a balance location of about 28 per cent of the mean aerodynamic chord, the moments of inertia about the *Y-Y* and *Z-Z* axes were increased about 800 slug-ft. squared by placing 555 lb. in the nose tank and 450 lb. in the rear tank without producing any appreciable change in spinning characteristics. This load distribution constituted a practical structural limit for this type of airplane and no further increase was attempted. It

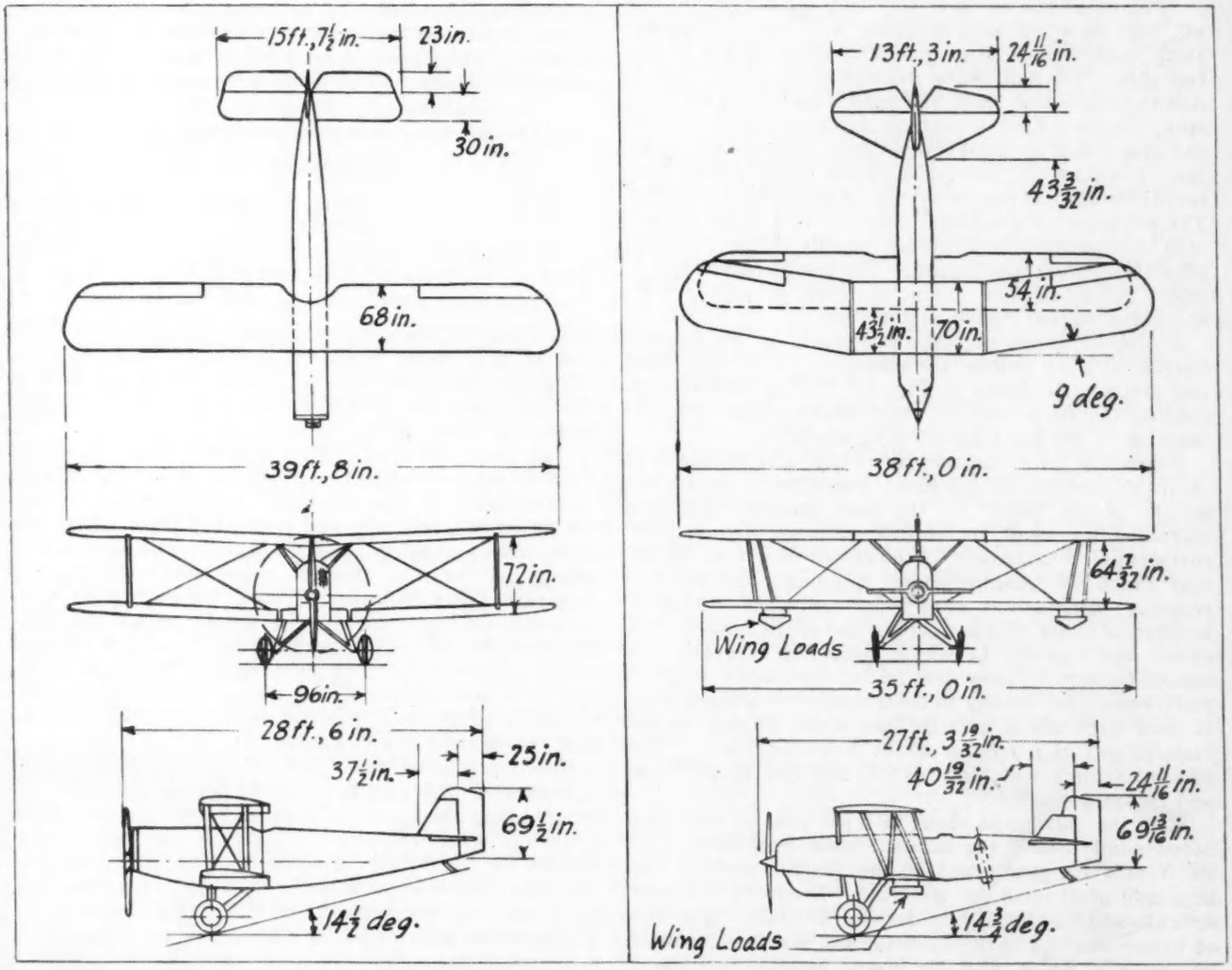


FIG. 1—GENERAL CHARACTERISTICS OF THE FIRST AIRPLANE TESTED

Ballast Tanks Were Placed in the Fuselage and Bomb Racks Were Installed on Each Lower Wing. Including the Ailerons, the Area of the Upper Wing Was 211 and of the Lower 200, or a Total Wing-Area of 411 Sq. Ft. The Area of the Vertical Fin Was 7 and That of the Rudder 12 Sq. Ft., or a Total Vertical Area of 19 Sq. Ft. The Area of the Stabilizer Was 37 and That of the Elevator 24.4 Sq. Ft., Making a Total Horizontal Area of 61.4 Sq. Ft.

FIG. 3—TESTS MADE ON AN AIRPLANE INCORPORATING BOTH SWEEPBACK AND STAGGER

The Method of Conducting Tests and the Observations Made Were the Same as for the Test on the First Airplane. The Total Wing-Areas, Including the Ailerons, Were 213.7 for the Upper Wing and 139.0 Sq. Ft. for the Lower Wing, the Total Being 352.7 Sq. Ft. The Area of the Vertical Fin Was 5.9 and That of the Rudder 11.7 Sq. Ft., or a Total Vertical Area of 17.6 Sq. Ft. The Stabilizer Area Was 28.2 and That of the Elevator 19.0 Sq. Ft., or a Total Horizontal Area of 47.2 Sq. Ft.

was found impracticable to increase the mass distribution along the vertical axis by any appreciable amount, and no tests of this nature were made, although it was realized that such tests were highly desirable.

Results of Tests

The tests on this airplane demonstrated that a rearward-balance location made recovery from spins more difficult, increase in lateral mass-distribution had a similar effect, longitudinal mass-distribution had no appreciable effect, power application had small effect and that the control positions used in attempting recovery had a marked effect. In cases of easy recovery, control positions were not important; but, whenever recovery became difficult, it was advisable to apply maximum reversed control immediately and to hold them fixed in the maximum positions.

"Pumping" the controls may help a seaplane to take-off, but, in a spinning airplane, it would be safer to jump than to depend on pumping the controls to stop the spin. The only safe method is to use all of the down elevator and all of the rudder motion against the spin, maintaining the controls in these positions until the spin stops or until low altitude necessitates jumping. Even a slight relaxation on the controls may mean the difference between stopping the spin and crashing. The ailerons are generally least effective in stopping a spin, the elevator and rudder usually being the most effective in the order named. The use of power was of slight benefit in some cases; however, in many of the spins, the engine ceased to function.

A similar series of tests was made on an airplane having a wing cellule incorporating both sweepback and stagger as shown in Fig. 3. The method of conducting the tests and the observations made were the same as in the tests on the first airplane.

Beginning with the airplane light and balanced at about 17 per cent of the mean aerodynamic chord, the weight of the ballast in the rear fuselage tank was increased by small increments between flights, with corresponding movement of the center of gravity to the rear, until an unsatisfactory spinning-condition was reached. These tests were concluded when a balance location of about 38.5 per cent of the mean aerodynamic chord was reached, at which point the recovery was unsatisfactory. Under the initial conditions the airplane responded readily to control action during a spin. It spun with the X axis inclined about 55 deg. to the vertical and at a rate of about 2 sec. per turn. The loss in altitude was between 200 and 250 ft. per turn and recovery was easy.

With the balance at about 38.5 per cent of the mean aerodynamic chord, the airplane spun irregularly with its X axis inclined about 30 deg. to the vertical and at a rate of about 3 sec. per turn. Recovery was very difficult and required considerable altitude. The use of power was not very beneficial and was accompanied by severe vibration, possibly due to variable gyroscopic torque of the propeller. These tests gave the same results so far as ease of recovery from spins was concerned at about the same balance location as in the first tests on an airplane having a very different wing-cellule arrangement. They also demonstrated that spinning attitude does not in itself indicate the ease of recovery since the first airplane spun "flat" when recovery was difficult, while the second airplane spun steeply with as great difficulty in recovery. The second airplane spun with its X axis most nearly horizontal with the balance well forward and, in this condition, recovery was very easy.

Lateral Mass-Distribution

The effect of increasing the mass-distribution along the lateral axis was investigated for two balance locations. A maximum of 400 lb. was placed in each wing tank with negligible effect on the ease of recovery from spins with the balance at 35 and at 27 per cent of the mean aerodynamic chord. The effects on speed of rotation and attitude of the airplane during a spin were also small. Variations of mass-distribution along the X axis also had negligible effect.

The different results secured by increase in lateral mass-distribution in these two airplanes indicated the importance of this factor and the desirability of using a staggered wing-cellule. It must be understood however, that these tests did not isolate any one factor as being solely responsible for the differences in recovery from spins in these two airplanes with increased lateral mass-distribution, since there were several differences other than in the wing-cellule arrangement. An exact test of this factor would have required changing the cellule arrangement on one of the airplanes without changing any other feature, and this was not practicable under the existing conditions.

TABLE 1—MOMENTS OF INERTIA ABOUT THE X, Y AND Z AXES

Axis	Moments of Inertia, Slug-Ft. Squared		
	First Airplane		Second Airplane
	Calculated	Experimental	Experimental
X	4,000	6,047	4,968
Y	4,400	5,404	4,734
Z	6,503	6,585	5,027

Upon completion of flight tests, the moments of inertia of the two airplanes about the X, Y and Z axes were determined experimentally by supporting the airplanes as a pendulum and swinging them about the three axes separately. (See Table 1.) The moments of inertia of the first airplane were later calculated to ascertain the possibility of their determination with sufficient accuracy during the design of an airplane. The test and calculated results about the Z axis checked within 2 per cent. The discrepancy about the other two axes was considerably greater, indicating the desirability of further investigation of the test methods and the method of calculation.

Investigation of the effect of length of pendulum showed that the results could be varied considerably by changing the length of suspension of the compound pendulum while there was practically no variation in results for the bifilar suspension. The bifilar suspension was used to determine the moment of inertia about the Z axis and the moments of inertia about the X and Y axes were determined by suspending the airplane as a compound pendulum. Suspensions were of about the same length in tests on both airplanes.

New Design Incorporates Data

Following these tests a new airplane of this type was designed to incorporate the useful information secured, and it was found to have satisfactory spinning-characteristics in addition to having improved flying-qualities. The same principles, if applied to many of the commercial airplanes produced in the last two years, would have eliminated much of the trouble and expense

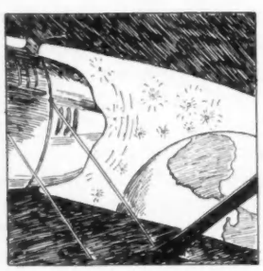
which some manufacturers have encountered. While much is to be learned about the causes of spinning, the effects of various factors and the manner in which airplanes should be designed to avoid spinning troubles, it is equally true that most of the designers who have had to redesign their airplanes to secure satisfactory spinning-qualities did not apply available information in the original design.

The tests on these two airplanes focused the attention of the Army Air Corps personnel on spinning to such an extent that many airplanes suddenly developed peculiar spinning characteristics and additional tests were made on various types with the anticipated result that no two types of airplane spin exactly alike; however, no others in service use at that time were found to be dangerous. One pursuit airplane in which the engine had been changed from a water-cooled to an air-cooled radial-type was found to spin much flatter with the radial engine and recovery was slightly slower; but the difference did not justify any attempt to secure the former characteristics in view of the fact that our present knowledge is barely sufficient to permit the design of airplanes which will recover from spins. Any attempt to modify an airplane to make it spin flat or steep, fast or slow or in any other specified manner, could be based only upon a guess as to the change required.

The problem at present is to secure reliable and sufficient data to assure that an airplane can be designed to provide easy recovery from any spins it may be capable of performing. Further refinements must await the results of extensive research. Tests were also made on several airplanes equipped with automatic leading-edge slots. In each case it was found that the airplanes could be spun and that, after they started spinning, the slots had no appreciable effect. It was somewhat more difficult to spin these airplanes, since the slots provided an increase in lateral stability at large angles of attack.

Rearward Weight Defeats Recovery

The foregoing tests showed that it is quite possible to load an airplane so that it will be impossible to stop a tail spin which has definitely started. Recovery from spins becomes increasingly difficult as weight is added behind the wings and the center of gravity of an airplane is moved rearward. The center of gravity may be moved so far aft that it becomes impossible to get the airplane out of a spin after it starts.



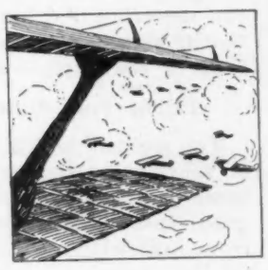
Since the loading condition affects recovery from spins, it is true that there are many different methods of using the controls which may stop spins under certain conditions of loading. There is, however, only one method which assures the quickest possible recovery with the least loss of altitude under all conditions of loading. This method consists of pushing the control-stick *all* the way forward, using *full rudder* in a direction to oppose the rotation and *holding them in these positions until the rotation stops*, after which the pilot can return the controls to neutral positions as quickly as he desires, thus controlling the resulting dive.

The importance of using this method increases with increase in the amount of control force necessary to get the stick all the way forward. The use of power makes little difference and, in some cases, makes recovery more difficult; hence it is best to forget about the engine in cases of difficult recovery and use every faculty to place the controls in the proper positions. If the engine quits in a spin, it can usually be started by diving, particularly if the airplane is rolled slightly in a direction opposite to the direction of rotation of the propeller. Dizziness can be reduced if the pilot refrains from moving his head unnecessarily during the spin. Turning around to look at the tail has a particularly bad effect.

Many manufacturers of airplanes have had difficulties with spinning and have made both laboratory and flight-test studies to determine the cause. This information should be made available in proper form for general use, since experiences have differed greatly and the change which cures one case may give very bad results in another very similar case. The history of most of these instances is known to the Department of Commerce, and the publication of this information by the Aeronautics Branch would greatly assist the industry in making improvements.

The National Advisory Committee for Aeronautics has recently started a comprehensive series of flight tests to determine the effects of various design-factors on spinning. To isolate each factor properly, the tests will necessarily require considerable time. In these tests all of the essential data are to be recorded automatically during the spins to determine the path of the airplane, accelerations and velocities about all axes, control positions and the like.

The factors which should be investigated include wing-cellule arrangement, balance location, mass distribution, vertical and horizontal tail-surface design, high-wing and low-wing monoplane arrangement and many other factors of presumably less importance. This investigation is of great importance and should be continued actively until definite conclusions of value to airplane designers are made possible. Since this study has been initiated rather late, it deserves an important position in the research program and the active support of the aviation industry.



Status of Research on Airplane Spinning

By Fred E. Weick[1]

THE AUTHOR describes briefly a recently developed method of accurately measuring the path of flight of an airplane in a spin and the attitude of the plane at each point in the spin. From these measurements the motion in a particular spin and the angles at which the various portions of the airplane advance into the air can be determined. He then reviews the actual spin measurements that have been made, mainly on models in wind tunnels.

An outline of the great number of factors affecting the spin is given, classified under the main headings: Aerodynamic Forces and Couples, Inertia Forces and Couples and Balance of Inertia and Air Forces, each with numerous subdivisions. Finally, those items on which research work has been done in this Country and in England are pointed out and brief statements of the principal results that have been obtained are presented.

THE PHENOMENON of spinning has apparently been known to some extent since the first days of flying, but for many years it was believed to be a dangerous evolution from which no one ever recovered. It was not generally known that recovery was possible until 1916, when a British pilot, Major F. W. Gooden, made a series of experiments in which he deliberately put his airplane into spins and brought it out by the use of the controls. After that the spin became an ordinary maneuver into which any except the largest airplanes might be put. Since then, however, and particularly in recent years when airplanes have been put into longer spins, difficulty has sometimes been experienced in recovering. This has given rise to considerable research, starting about 12 years ago, but the problem is so complex that results which can be satisfactorily used in a general way are just starting to come in. In this paper I hope to cover briefly the present status of spinning research and the main results obtained to date. Only the steady spin and the recovery from it will be considered, not the problem of avoiding the spin entirely.

FRED E. WEICK

One of the greatest advances in research on spinning has just recently been accomplished. That is the development of a method of accurately measuring just what an airplane does in a spin; that is, its path of flight and its attitude at each point. We can therefore now know just what the motion in a particular spin is and the angles at which the various portions of the airplane advance into the air.

Flight Path Calculated from Measurements

The method, which has been developed over a period of years, is to measure the rates of rotation about the three principal axes of the airplane by means of three gyroscopic turnmeters, the accelerations about the same three axes with a three-component accelerometer placed at the center of gravity, and the vertical velocity. Measurements are also made of the positions of the controls, these, as well as the rotations and accelerations, being recorded photographically. In making a test, the spin is maintained for about 1000 ft. before the instruments are started, and then the instruments are run for exactly 1000 ft., the rate of descent being obtained from timing lines on the records. Then, from the rates of turn and the accelerations obtained from the records, calculations are made of the flight path, the radius, the attitude of the airplane, and the inertia couples. For this the moments of inertia of the airplane about its principal axes must be known, and this has also been a stumbling block which has taken several years to solve satisfactorily. The moments of inertia are obtained by swinging the airplane as a pendulum mounted on knife-edges, and the process has finally been developed to the point where the results are accurate to within 1 per cent.

It is of interest to review the actual spin measurements that have been made so far. The first noteworthy point is that the center of gravity of the airplane moves in a very steep helix, the radius being very small compared with the general idea. This radius is usually about 6 ft., the extreme values measured to date being a minimum of 3 and a maximum of a little more than 9 ft. The spin axis, or center of rotation, has in every case measured been close to the nose of the airplane, as shown in the top view in Fig. 1. Obviously, the airplane spinning about such an axis has an entirely different motion from that in an ordinary spiral glide of the same vertical velocity, in which case the rotation is about an axis far to one side of the airplane, as indicated at the upper right.

The attitude of the longitudinal axis of the airplane varies in different spins from the steepest, at about 60 deg. to the horizontal, to the flattest, at about 30 deg. to the horizontal, as shown in the side view of Fig. 1. The 30-deg. angle was obtained in the case of the NB-1, the airplane that introduced the "flat spin." It is likely that these angles represent very nearly the maximum limits that can be obtained, for the main couple which tends to flatten the spin—the inertia pitching-couple—has a maximum value for an attitude of 45 deg. and becomes very small for small angles, whereas, at the steep end, the airplane could not have an attitude much closer than 30 deg. to the vertical and remain stalled. The mean angles of attack at the center of the wings, therefore, vary from about 30 deg. for the steepest to about 60 deg. for the flattest spins. The difference in angle of attack from one wing tip to the other is great in any spin, this difference varying

[1] M.S.A.E.—Aeronautical engineer, National Advisory Committee for Aeronautics, Langley Field, Va.

from about 20 deg. in a slow spin to about 70 deg. in a rapid one, the average being in the neighborhood of 35 to 40 deg.

That the tail unit operates under very poor conditions is evident from a glance at Fig. 1. The angle of attack is from 30 to 60 deg. This is combined with a sideslip in the neighborhood of 20 deg., and the fin and rudder are usually almost entirely in the wake of the horizontal surfaces. In spite of this, the rudder seems to be the most effective of the controls for coming out of a spin, which may be partly due to the rudder being the only control not stalled and partly to the effect the rudder has on sideslip. At any rate, it seems that an intensive study of the tail group in a spin should be well rewarded.

Most Tests Made on Models

Flight tests are rather limited in research work, for suitable changes in the airplane are difficult to make and take considerable time. There is also a hesitancy to include extreme conditions because of the dangers involved. Some tests were made a few years ago in which spinning scale-models were dropped through a distance of about 100 ft. in the balloon hangar at Langley Field, Va., and motion pictures taken of them. This method has the advantage that extreme cases can be tried without danger except to the model, but the results are difficult to measure. Only one series of tests made at that time showed interesting results, but if sufficiently developed the method might yield a valuable fund of information.

Most investigations in regard to spinning have been made on models in wind tunnels. These include the ordinary lift and drag tests run up to high angles of attack, as well as rotation tests. The rotation tests have been of two kinds: first, those in which the model is allowed to rotate freely and the rate of rotation is measured at the various angles of attack; and, second, those in which the model is mounted on a dynamometer which rotates it at certain angular velocities and measures the torque or rolling moment. Both cases correspond to spins with zero radius, but, since the actual radius is very small, the air-flow over the wings is very nearly the same. This is not true, however, for the flow over the tail. Although these methods have many limitations, both in the inaccuracy of the air-flow reproduced over the airplane as a whole and in the limited information they yield, almost all of the valuable research work on the aerodynamic characteristics of the wings in a spin has come from them.

Building Vertical Tunnel for Spinning Tests

The National Advisory Committee for Aeronautics has just built at Langley Field a vertical wind-tunnel for autorotation and spinning tests. A spinning rig is now being designed for this tunnel, with which it will be possible to reproduce the conditions of a full-scale spin as far as the radius, rotational velocity, vertical velocity and attitude of the complete model-airplane are concerned. Thus, the air-flow over the entire model will be reproduced accurately, except for what scale effect there may be. Under these conditions a complicated balance incorporated in the spinning rig will measure the three components of forces and moments about the center-of-gravity position. Investigations with this apparatus should give reasonably accurate and very valuable information in regard to the effects of various types of tail surface, controls, fuse-

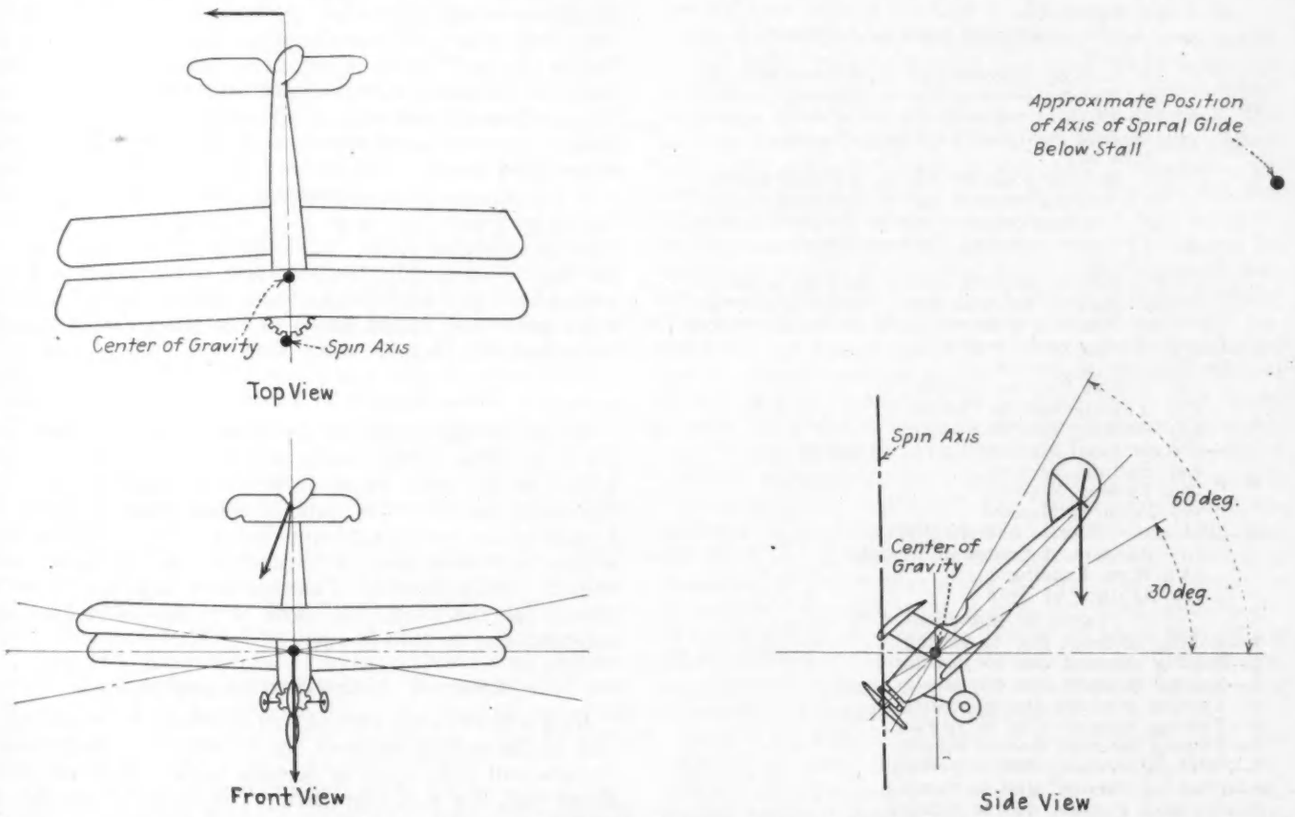


FIG. 1—ATTITUDE OF THE AIRPLANE IN A TYPICAL SPIN

lage shape and general arrangement, none of which can be obtained satisfactorily with the ordinary autorotation tests. Unfortunately, the apparatus must be quite complicated and it will be some time before it is producing results.

Cause and Range of Autorotation

If the normal-force coefficient of a typical wing, which represents the force perpendicular to the chord, is plotted for angles of attack up to 90 deg., the resulting curve is similar to that in Fig. 2. Now, if an airplane is flying at an angle of attack above that for maximum normal force, and something, say a quick aileron movement or a gust, gives the airplane a rolling motion, the up-going wing tip will have a smaller angle of attack but a larger lift, and the tip traveling downward will have a higher angle but a smaller lift. The upward-moving tip will therefore tend to continue moving upward, and the other will tend to continue downward, resulting in a continuous turning, called autorotation.

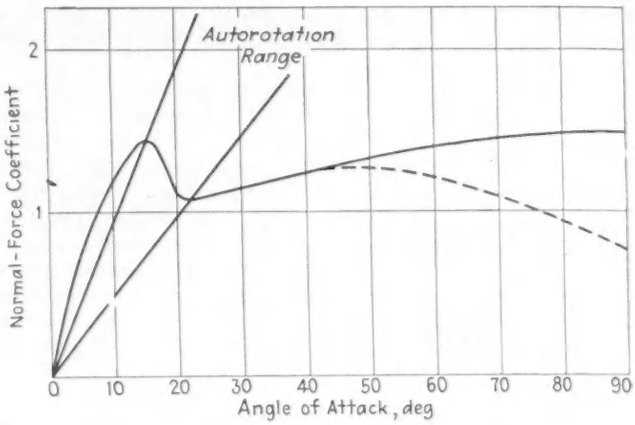


FIG. 2—TYPICAL CURVE OF NORMAL-FORCE COEFFICIENT PLOTTED AGAINST ANGLE OF ATTACK

This can be easily demonstrated in a wind tunnel in which a model wing is mounted so that it is free to turn about a longitudinal axis parallel to the air-flow. The results of many wind-tunnel autorotation-tests with model wings show conclusively that there is a definite relation between the slope of the normal-force coefficient curve and the range of angles in which autorotation will occur. Where the slope is steeply upward, as below the stall, there is no autorotation, but where the slope is definitely downward it will occur. The range cannot be predicted with great exactness by this means, particularly between the stall and about 35 deg., but above and below those limits the indication is reliable for the simple wind-tunnel conditions mentioned. If, however, other factors such as sideslip come into play, the autorotation range may extend all the way up to 90 deg. Thus, while the spin and autorotation are inseparable, autorotation includes many more factors than have been investigated in the simple wind-tunnel tests which have been made with it so far.

TABLE 1—FACTORS AFFECTING STEADY SPIN

I—Aerodynamic Forces and Couples

A—Airfoils
- (*a*) Sections 1 to 36
- (*b*) Slots 1 to 36
- (*c*) Flaps 1 to 36

B—Variation along Span
- (*a*) Plan Form 1 to 36
- (*b*) Sweepback 1 to 36
- (*c*) Dihedral 1 to 36
- (*d*) Washout 1 to 36
- (*e*) Change of Section 1 to 36

C—Biplane and Multiplane Combinations
- (*a*) Gap 1 to 36
- (*b*) Stagger 1 to 36
- (*c*) Decalage 1 to 36
- (*d*) Different Sized Plane Combinations 1 to 36
- (*e*) Pilot Planes 1 to 36

D—Tail Surfaces
- (*a*) Relative Size 1 to 36
- (*b*) Distance from Center of Gravity 1 to 36
- (*c*) Shape and Arrangement 1 to 36
- (*d*) Airfoil Sections 1 to 36
- (*e*) Fuselage Shape and Interference 1 to 36

E—Control Surfaces
- (*a*) Ailerons Deflected Various Amounts
  - 1 to 36
  - 37—Rolling moment due to deflected ailerons
  - 38—Yawing moment due to deflected rudder
  - 39—Pitching moment due to deflected rudder
- (*b*) Rudder Deflected Various Amounts
  - 1 to 36
  - 37—Rolling moment due to deflected rudder
  - 38—Yawing moment due to deflected rudder
  - 39—Pitching moment due to deflected rudder
- (*c*) Elevator Deflected Various Amounts
  - 1 to 36
  - 37—Rolling moment due to deflected ailerons
  - 38—Yawing moment due to deflected ailerons
  - 39—Pitching moment due to deflected elevator

II—Inertia Forces and Couples

A—Ellipsoid of Inertia
- (*a*) Rolling Inertia Couple
- (*b*) Yawing Inertia Couple
- (*c*) Pitching Inertia Couple

B—Precessional Moment Due to Propeller
- (*a*) Rolling Moment
- (*b*) Yawing Moment
- (*c*) Pitching Moment

III—Balance of Inertia and Air Forces
- (*a*) Position of Center of Gravity
- (*b*) Wing Loading
- (*c*) Altitude of Spin

TABLE 2—SUB-ITEMS 1 TO 36

1—Rolling moment due to rolling
2—Rolling moment due to yawing
3—Rolling moment due to sideslip
4—Yawing moment due to rolling
5—Yawing moment due to yawing
6—Yawing moment due to sideslip
7—Pitching moment due to rolling
8—Pitching moment due to yawing
9—Pitching moment due to sideslip
10 to 36—Similar factors of less probable importance

Main Results of Research to Date

To study the spinning problem from the research point of view, I have made an outline of the factors affecting the spin, which is given in Tables 1 and 2, the subheads 1 to 36 in Table 1 being given in Table 2. I shall point out briefly the items in this outline on which work has been done and the main results obtained. Unfortunately, I cannot give individual credit herein for the work, but most of it has been done in England and in this Country.

Effect of Airfoil Section and Slots

Item IA (*a*) 1.—In regard to the effect of airfoil section on the rolling moment due to roll, all airfoils tried to date will autorotate at certain angles of attack just above that for maximum lift. The slope of the curve of the normal-force coefficient versus the angle of attack

is a good criterion below the maximum lift and above 35 deg., but cannot be relied upon between these points. In general, sections having sharp peaks to their lift curves have high rotating moments.

*Item IA(a)*3.—Wind-tunnel autorotation-tests, in which sideslip is introduced by setting the airfoil at a certain angle of yaw, show that sideslip, if present, is a very important factor. It affects the rolling moment in the sense that it makes the forward wing-tip tend to rise. Twenty degrees of sideslip in the direction aiding rotation approximately doubles the rolling moment and extends the range of autorotation up to 90 deg., whereas 20 deg. of sideslip in the other direction will usually overcome the rolling moment due to rolling and tend to make the wing turn in the opposite direction. The amounts of sideslip that have been measured in spins have been between zero and 10 deg.

*Item IA(b)*1.—Wind-tunnel auorotation-tests with slotted R.A.F.-15 and R.A.F.-31 airfoils show that, with slots all along the leading edge, the angle of maximum lift, and therefore the beginning of the autorotation range, is delayed about 10 deg., say from 15 deg. to 25 deg., but that above this both the range and the unstable rolling moments due to rolling are much greater. With ordinary airplane-controls the autorotation range may never be reached. One airfoil with tip slots only was tried, and this had a weak autorotation-range from 17 to 20 deg., and then a moderate one above 40 deg.

Effect of Wing-Span Variation

*Item IB(a)*1.—Judging from rather meager tests with different plan forms, neither taper nor aspect ratio has important effects on autorotation.

*Item IB(b)*1.—Sweepback reduces both the rate and range of autorotation to the extent that 30 deg. of sweepback eliminates it entirely, but with very low damping.

*Item IB(b)*3.—With 30 deg. of sweepback and sideslip, if the sideslip is 10 deg. or less, the rotation is quickly damped and sometimes slowly reversed, but if the sideslip is greater than 15 deg. there is rapid autorotation even with the sweepback.

Results with Various Wing-Combinations

*Item IC(a)*1.—A biplane having the gap equal to the chord and zero stagger has a much larger range of autorotation than a monoplane, the range extending up to 90 deg. instead of to only about 40 deg. Reducing the gap increases both the range and rate, but the effect is small.

*Item IC(a)*3.—Sideslip increases rolling moments less with a biplane than with a monoplane. Sideslip in the other direction of 20 deg. in one case and 30 deg. in another completely stopped autorotation at any angle of attack.

*Item IC(a)*7.—The pitching moment due to rolling was measured for the case of a biplane with zero stagger and small gap, and was found to be a small moment tending to raise the nose.

*Item IC(b)*1.—Several tests have shown that increasing positive stagger reduces both the range and rate of autorotation, tending to make the biplane act more nearly after the manner of a monoplane. The effect is much greater than that of gap.

*Item IC(c)*1.—Some meager early tests indicate that positive decalage slightly reduces the rate and range of autorotation.

*Item IC(e)*1.—One series of tests has been made on a main plane with a small auxiliary plane mounted some distance above and ahead of the leading edge. With this auxiliary plane set at −20 deg., the combination had no autorotation but had a high minimum drag. The curve of normal-force coefficient versus angle of attack had no definite negative slope but was slightly wavy at the angles corresponding to maximum lift. This may possibly be a fruitful field for non-spinning combinations.

Effect of Tail and Control Surfaces

Item ID.—Very little work has been done on the effect of tail surfaces, although this is probably one of the most helpful fields. In one autorotation test of a complete model of an English Springbock, the rotation was appreciably slower with the tail in place than when it was removed. The fuselage also helped to slow down the rotation, but very slightly. In another case, that of the English Bantam, the rotation was faster at high angles with the tail in place than with it off; in fact, the model would autorotate with the wings removed. Apparently the tail surfaces can either aid or hinder the autorotation.

*Item IE(a)*1.—Two experiments have been made with model biplanes having all of the ailerons rigged up at angles of deflection up to 15 deg. Both sets of tests showed large reductions in both the rate and the range of autorotation. Floating wing-tip ailerons in one experiment appreciably reduced the rate of autorotation and the rolling moment due to rolling. Interplane floating ailerons had very little effect on one biplane model but reduced both the rate and range of autorotation on another on which the ailerons extended a certain distance beyond the tips of the wings.

*Item IE(a)*37.—Autorotation tests have been made with a model biplane having the ailerons deflected in opposite directions as they ordinarily are for control purposes. The rate of rotation increased when the ailerons were deflected to aid it, while a 6-deg. deflection in the opposite direction stopped the rotation. In another case the rotation was reversed by one aileron being deflected up 40 deg. and the other held at zero. In this case the effect was quite positive. It should be remembered that in this and other cases where it was not specifically mentioned, the tests were made without sideslip and other factors which would probably entirely change the results. In a full-scale spinning-test on an airplane having a very powerful lateral control at high angles, consisting of ailerons, slots and interceptors, reversing the controls slowed down the spinning rate a large amount but would not stop the spin with the stick back unless the rudder were neutralized.

*Item IE(b)*38.—Although the rudder seems from experience to be the most powerful control in a spin, and the rotation can usually be stopped or at least reversed by means of the rudder alone, virtually no information is available on just what it can be relied upon to do. It seems likely that it may derive at least part of its effect indirectly through its influence on the sideslip. At any rate, it furnishes a promising field for spinning research in the vertical wind-tunnel.

*Item IE(c)*39.—Although it would seem that the pitching moment due to forward stick and down elevator should be an important item in getting out of the stalled range in recovering from a spin, very little information is available on the subject. That present

elevators are not sufficient in themselves to effect recovery has been shown in two cases in which pushing the stick forward in a spin, with the rudder held over, increased the rate of rotation instead of stopping the spin.

Inertia Forces and Couples

Item IIA.—The inertia forces and couples in any given spin are well understood and can be accurately calculated if the moments of inertia of the airplane and the path and attitude of the spin are accurately known. Apparently the most important inertia factor is the pitching couple, which in all conventional airplanes tends to increase the angle of attack and flatten the longitudinal attitude. What is not known is the exact effect on the spin. Some fairly enlightening tests have been made, however, which show that the mass distribution may be of prime importance in some cases. Most of these tests have been made in flight, but the most revealing was a free-dropping test with a model of the original flat-spinner, the NB-1.

The model was arranged so that the mass distribution could be changed along the Z or vertical axis by moving equal weights in or out on a rod that extended above and below the model. The loading and the position of the center of gravity were unchanged. With the weights in, the model spun at the same flat attitude as the full-size airplane, 30 deg. to the horizontal. With the weights moved farther and farther out, it spun with a steeper and steeper attitude until an angle of about 60 deg. to the horizontal was reached. With the weights still farther out, the model would not spin at all but toppled in a series of irregular gyrations. Motion pictures of the two extreme spins and of a spin of the full-scale airplane were taken.

In the cases of two models of an Army observation plane, full-scale spin-tests were made with different mass distributions along the Y or lateral axis. In one case no difference was noticed in the spins, but in the other spreading out the mass laterally made recovery more difficult.

Item IIB.—The precessional moment due to the propeller is in the same state as the other inertia couples in regard to both the possibility of calculation and in that the most important effect is due to the pitching moment. With right-handed propellers, which are standard in this Country, this moment tends to raise the nose in a left-hand spin and depress it in a right-hand spin. It is not ordinarily of great importance when the engine is throttled, but makes a large difference in left and right-hand spins if power is used.

Item III.—The balance of the inertia and air forces and couples is apparently of some importance, but little is known in regard to it. The fore-and-aft location of the center of gravity with respect to the wing chord seems to be important in some cases and unimportant in others. Army and commercial tests both indicate that difficulty in recovery is to be expected if the center of gravity is farther back than about 35 per cent of the mean aerodynamic chord. The exact location between about 20 and 35 per cent apparently is not critical.

Summary

Summarizing, it is evident that the spinning problem is made up of a multitude of factors the relative importance of which must be determined before the solution of the problem can be considered well under way. Some progress has been made, however, for we can now at least measure what a spin is and calculate the inertia forces and couples. Also, tests have been made, many of which are admittedly crude and incomplete, on about 20 of what seem to be the more important of the factors given in the outline in Tables 1 and 2, which total about 800 and are not complete. While most of these are of little or no importance, we must not overlook any that may be important if we desire to solve the problem completely. And, while the problem is still a very large one, conditions are more hopeful than they have been before, for we are now for the first time in a position to expect accurate and valuable results from flight tests, and we also expect to be getting the same from model spinning-tests in the vertical tunnel where the effect of the tail group can be studied in detail.

Safety *and* Serviceability *in* Primary Gliders

Detroit Aeronautic Meeting Paper

By William J. Perfield[1]

THOSE WHO have had the good fortune to fly in a glider have been greatly impressed by the experience. Even veteran airplane pilots are enthusiastic about the thrill of gliding. It has struck the fancy of American youth and, just as the perfection of the automobile changed Dobbin's harness to a saddle and the development of power boats relegated the sailboats almost entirely to sporting pursuits, it now seems that the advent of the airplane is to establish gliding as a sport.

The practical value of gliding to modern aviation is much debated. Certainly it is in some respects an asset to the aeronautic industry, but the liability that it may become if not properly directed is of great concern at the moment.

Glider clubs are springing up all over the Country. Thousands of young men and women are eagerly grasping the opportunity afforded of getting into the air economically and, we hope, safely. Many commercial gliders are being sold but very often the gliders are privately built. High-school students and young working-men without any knowledge of aircraft structures and flight loads are working from incomplete blueprints and cheap-magazine plans. Materials of questionable quality are often substituted when specifications cannot be met. Such conditions are sure to spell disaster sooner or later, especially with the present tendency toward automobile towing, which increases the normal flying-altitude of 30 or 40 ft. to as much as 800 ft.

The aeronautic engineer is better qualified than any other individual to check this alarming situation. Whether he is or is not interested in personal participation in the sport, he is in a position to do the industry at large a great service by making his technical knowledge and experience available to the glider designer and constructor in the interest of the safety of the amateur glider-enthusiast.

Actual participation in the activities of a glider club will perhaps accomplish most in this respect. If the club intends to build a glider, the engineer can be of great service. He may design one to suit the particular needs of the club or may advise on the selection of plans. In the shop he can inspect materials and workmanship and iron out the little structural difficulties that are sure to arise. If the glider is to be bought, his advice on its selection should be sought. The supervision of repairs is also an important function of the technical advisor.

The aeronautic engineer's experience qualifies him at once to judge the airworthiness of a glider, because of its aero-dynamic and structural similarity to the airplane. There are, however, other considerations which a person who is inexperienced in the handling and building of gliders might overlook in designing or appraising one. In this paper the purpose will be to point out and discuss some of the factors that should be borne in mind in designing or selecting a primary training glider and to describe some of the structural details that make for simplicity of construction.

Gliding is in some respects an asset to the aeronautic industry, but the liability that it may become if not properly directed is of great concern at the moment.

Many commercial gliders are being sold, but very often the gliders are privately built. High-school students and young working-men without any knowledge of aircraft structures and flight loads are working from incomplete blueprints and cheap-magazine plans. Materials of a questionable quality are often substituted when specifications cannot be met.

The aeronautic engineer is better qualified than any other individual to check this alarming situation. He is in a position to do the industry at large a great service by making his technical knowledge and experience available to the amateur glider-enthusiast in the interest of safety.

In this paper the purpose is to point out and discuss some of the factors that should be borne in mind in designing or selecting a primary training glider and to describe some of the structural details that make for simplicity of construction.

Primary-Glider Design

The main function of the primary training glider is to give safe, economical instruction in the rudiments of handling aircraft. To fulfill these requirements, performance is of secondary consideration. Stability and strength in the air, ruggedness on the ground and facility of transportation, in the order named, precede in importance aerodynamic refinement. The importance of stability and ruggedness is apparent, but that of facility of transportation can be appreciated only after some experience. Contests, license-test flights and exhibitions require surprisingly frequent removals. The task of knocking down, loading, unloading, setting up and rigging the average primary glider requires many man-

[1] Designing engineer, Stout Engineering Laboratories, Dearborn, Mich.

hours of painstaking work which could be avoided by spending a little extra time on the drafting-board and in the shop.

Weight is of little consequence in the primary glider, except that excessive weight makes handling on the ground more laborious, especially when using shock cord. The average primary glider weighs between 175 and 200 lb. More weight is unnecessary; less is unsafe, unless unwarranted refinements in design and construction are made.

Wing loading should be kept between 2 and 2.25 lb. per sq. ft., allowing 170 lb. as the weight of the pilot. This will make the area 160 to 175 sq. ft. Lighter loadings make a ship unsafe for the novice to handle, especially in gusts. Higher loadings increase the landing speed and gliding angle.

Since the gliding angle is the criterion of glider performance, the L/D ratio will govern the selection of the airfoil. A good glider section should have a maximum L/D of 18 or 20 and a maximum-lift coefficient of not less than 1.2. Sections with sharp burble points should be avoided. The U.S.A. 35-B, the Clark-Y and several of the Göttingen sections have all been used with good results. The M-6 and M-12 have good gliding characteristics but are too fast for primary training. Thick sections such as the Göttingen 387 are undesirable. Besides having high drag-coefficients, their depth is too great for the size of spars required. A 12-per cent section has about the right depth.

WILLIAM J. PERFIELD

Good longitudinal stability will be obtained by placing the center of gravity at the maximum forward position of the center of pressure. Since the glider has no heavy engine on the nose, the pilot must be placed well forward for balance. Usually his center of gravity is almost directly under the leading edge of the wing. With the pilots' center of gravity so far ahead of that of the glider, variations in the weight of the pilot, which is almost half the gross weight, make accurate balance impossible unless an adjustable seat is provided. However, if care is taken to avoid excessive tail-heaviness with light pilots, this provision will not be necessary, although it would be desirable if some simple means of adjustment could be devised.

Special provision for lateral stability is not necessary. Dihedral is sometimes used, however, and the landing-wire cabane is often made to serve as a skid fin.

Desirable Type of Glider for Training

In the selection of a glider for primary training we have been influenced to some extent by German experience. The type classified by the Germans as the Zoegling, shown in Fig. 1, has been used a great deal in this Country. It consists of an open-lattice-work fuselage, if it may be called such, usually of wood; a wood-and-fabric wing attached to the fuselage by wires; and a wooden skid for landing. It is controlled by the conventional stick and rudder-bar.

The obvious feature of a glider of this type is its simplicity of construction and ease of repair. It also has an advantage in that it places the pilot completely in the wind so that he can better judge his speed. Being full exposed also requires the student to balance the glider entirely by "feel" and sound, as he has no reference point to keep on the horizon. Unobstructed ground visibility facilitates landing and minimizes the chances of crack-ups from this source.

From a translation from *Flugsport* of Dec. 11, 1929, we learn that the Breslau Glider Club now attaches to the Zoegling a hood or cowling that encloses the pilot. This is used to accustom the students to cockpit flying in preparation for soaring and power flight. According to the report, this cowling and other slight refinements decreased the gliding angle of the glider from 1:8 to about 1:12. However, the club still gives the first few hops in an open model.

At present a movement is under way in this Country to adopt what is known as the utility glider, which consists of an enclosed fuselage and a wing with an aspect ratio of about 7 supported by lift struts, as illustrated in Fig. 2. The arguments in its favor are its greater durability, ease of set-up and dismounting, better appearance and better performance. Under favorable conditions this type of glider can be soared for hours. The same glider can therefore be used for both primary and advanced training.

Shock-Cord Launching versus Automobile Towing

The design of the fuselage and landing-gear depends to a great extent on the method of flying to be used.

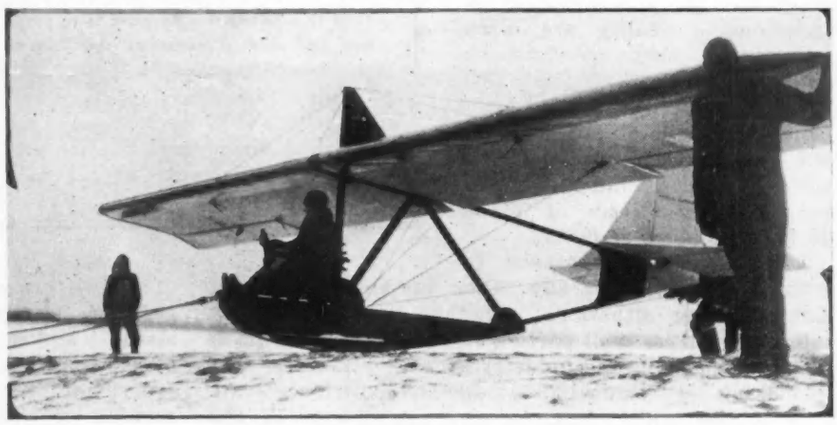


FIG. 1—ZOEGLING-TYPE GLIDER FOR PRIMARY TRAINING

Miss Amelia Earhart in the Pilot's Seat. Note the Large Number of Brace Wires

There is much discussion in the Country as to the relative advantages of shock-cord and automobile towing for flight training. The Germans use the shock cord almost entirely. One reason for this is apparent when we read in the article mentioned: "Our training terrain is 15 miles from the city and is usually reached by our members by bicycle, thus reducing the cost of transportation." Apparently, gliders are more plentiful than automobiles in Germany. Few Americans would ride a bicycle 15 miles for the privilege of an occasional hop, and would soon rebel at pulling on the shock cord and carrying the glider back up the hill.

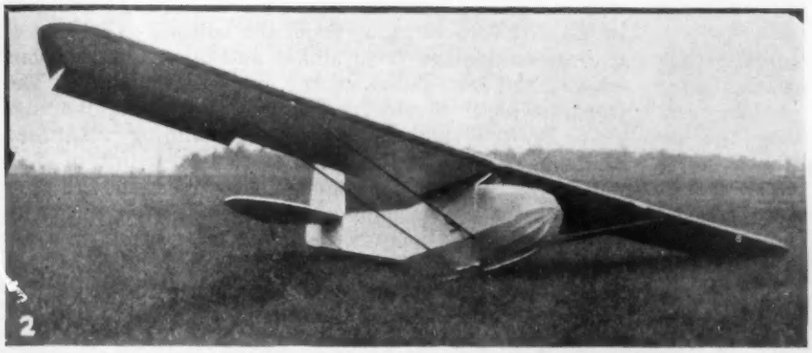
Aside from the labor involved, shock-cord flight has other disadvantages. A ground crew of at least six is required to launch a beginner by this method; more advanced fliers use as many as 20 in the ground crew. The acceleration received at the start is often bewildering to the student, who, upon finding himself so suddenly pitched into the air, confuses his instructions, goes into a stall and comes down to a hard landing.

Automobile-tow flights can be conveniently managed by three persons besides the pilot, and may even be handled by two. With a little practice the glider can be flown back to the starting point, thus reducing the handling to the minimum. The question of safety is often raised, the argument being that the altitudes attained by automobile towing are dangerous for students. Of course, if students were sent up 200 or 300 ft. for their first flight, such fears would be well founded. The usual method of training, however, is to tow the student along the ground with just enough wind speed to make the controls effective. Either the stick can be held forward or the controls can be rigged so that the elevators cannot be raised. This gives ideal training in trimming the plane by means of the ailerons and rudder. When the student has progressed to the satisfaction of the instructor, he is permitted to make a few short hops. The instructor can limit the altitude attained by slowing down the tow car. As the length of the hops increases, the student acquires confidence and is soon ready for banks and spot-landings.

Selection of a Landing-Gear

A plain skid is the most practical undercarriage for shock-cord work. It is by far the cheapest and simplest and, because of the character of the ground usually found on gliding terrain, is the most serviceable. The friction of the skid on the ground does not in any way hinder the take-off, because the high acceleration puts the glider in the air after a very few feet of travel on the ground. The landing run is decreased by the friction of the skid, which also prevents the glider from rolling backward in event that it is landed on a slope. When no dolly is provided, however, the glider must be carried back up the hill unless a horse is available. A simple dolly can be made from coaster-wagon wheels.

Some sort of shock-absorber is desirable though not essential in a pri-



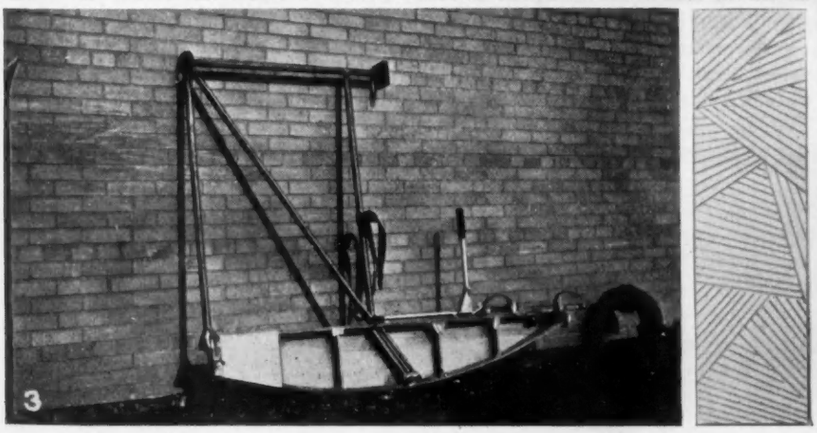


FIG. 2—UTILITY GLIDER FOR PRIMARY AND ADVANCED TRAINING

Designed and Built by the Franklin Glider Corp., of Ypsilanti, Mich., Which Developed the Landing Skid Having a Low-Pressure-Tired Wheel Mounted under the Center of Gravity and Projecting One-Quarter of Its Diameter through an Opening in the Skid

FIG. 3—SKID DESIGN FOR A ZOEGLING-TYPE GLIDER

As the Skid Is Not Braced Ahead of the Front Lift-Strut, the Forward Portion Is Reinforced

FIG. 4—SKID BRACED AGAINST SIDE LANDING LOADS

Constructed by the Akron Glider Club. Note Height of Lift-Cable Fitting To Prevent Damage from Stakes or Other Ground Obstructions

mary glider. However, to design one that will satisfactorily resist side loads is difficult. Springs, rubber blocks and air cushions have been used with fair success in some instances, but any such arrangements complicate repairs and for this reason are usually avoided.

For automobile towing, the wheel gives the best results. Take-off by this method is not so rapid as by shock cord and the continual dragging around the field causes excessive wear on a skid.

Double skids and two-wheel landing-gears are seldom used. With the single-truss type of fuselage, the increased structural weight and air resistance necessary to secure sufficient tread for stability on the ground is not warranted by the added convenience. The fact that the glider must rest on a wing tip often worries the uninitiated. It is found, however, that after a level landing the wing tip can be set down very gently.

FIG. 5—AN AIRWHEEL LANDING-GEAR

The Shock-Absorbing Quality, with an Air Pressure of about 5 Lb. per Sq. In., Greatly Reduces Landing-Impact Stresses and the Wheel Will Withstand Heavy Side-Loads. The University of Detroit Glider Club Has Had Success with This Construction

For the beginner, the two-wheel undercarriage has the advantage that it permits the mastery of the rudder before attempting the coordination of rudder and aileron, thus reducing the dragging of wing tips on the ground. It also eliminates running with the wing tip while taxiing down or across wind. The latter, however, is not so important, because an experienced pilot can taxi behind a car unassisted in quite a stiff breeze once he is started. A detachable two-wheel undercarriage might have possibilities for training beginners.

A landing-gear combining the advantages of the skid and wheel has been developed by the Franklin Glider Corp., of Ypsilanti, Mich. A single low-pressure tire is mounted directly under the center of gravity of the glider. About one-quarter of its diameter projects through an opening in the skid (see Fig. 2). The glider is therefore balanced on the wheel but is prevented by the skid from nosing over or riding on the tail. This type of undercarriage has the unique advantage that the forward portion of the skid can be made to serve as a very effective brake by depressing the elevators after landing, which throws the weight on the nose, causing deceleration by ground friction.

The Design of a Skid

The design of a satisfactory skid for a Zoegling involves more, perhaps, than is at first apparent. The chief concern is provision for side landing. The skid is not usually braced ahead of the front lift-wire or lift-strut fittings because of the inconvenience of any such bracing (see Fig. 2). The only solution then is to reinforce the forward portion of the skid. Sometimes this part is made detachable at the front-lift-wire fitting to make replacement easy. The fact that the lift wires usually are attached to the skid 8 to 12 in. up from the bottom, as in Fig. 4, to prevent damage from stakes and other obstructions, adds to the seriousness of the side landing-loads. The Department of Commerce requires that glider landing-gears be investigated for the same landing conditions as the airplane, using a minimum load-factor of 5.

Hickory or ash is usually used for the runner, although either wood or steel, depending on the fuselage construction, may be used for the rest of the skid. The width of the runner should be 3 or 4 in. It is steamed and bent to the required curvature before being attached to the skid. The curvature of the runner determines to a great extent the take-off characteristics. Flat bottoms should be avoided. The curve should be such that the skid will act as a rocker during the take-off, thus enabling the angle of attack to be varied by the elevators. If this precaution is not observed, it will be found very difficult to take off with a heavy pilot unless the wings have considerable incidence. To

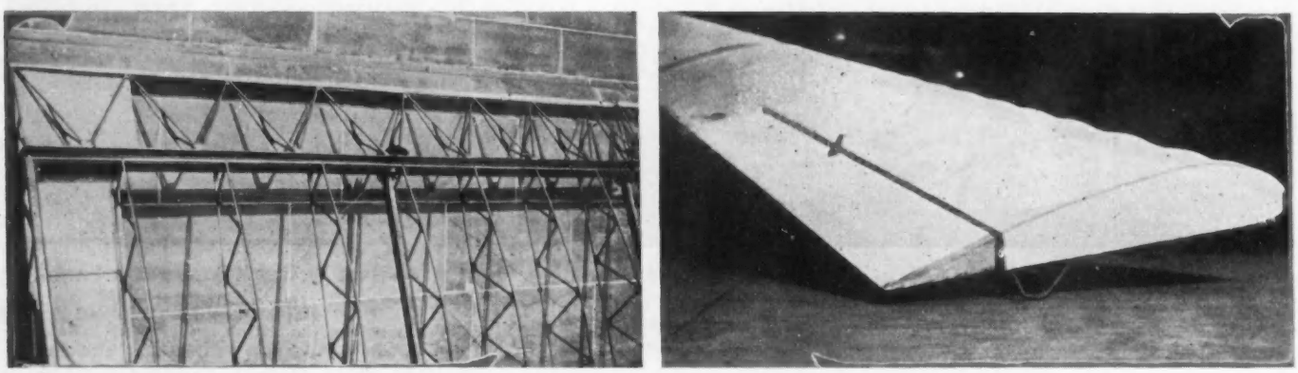


FIG. 6—METAL WING AND AILERON CONSTRUCTION BEFORE AND AFTER COVERING

The Aileron Is of Truss Type with Plywood Reinforcements on the Tip. As Shown at the Right, the Wing Has a Metal Skid. However, This Does Not Protect the Aileron and Has Not Sufficient Width To Slide Smoothly on the Ground

reduce fuselage stresses, the rear portion of the skid should be so shaped that there is little possibility of the tail post touching the ground. This will also protect the lower longitudinal and the elevators from damage.

Design of a Wheel Landing-Gear

The University of Detroit Glider Club has had very good success with a single 16 x 7-in. Airwheel mounted between the front lift-struts as shown in Fig. 5. The Airwheel probably will withstand more side load than any of the rest of the structure and its shock-absorbing qualities greatly reduce the landing-impact stresses. An air pressure of 3 lb. per sq. in. was first used but was found to be insufficient. A pressure of about 5 lb. was found to be necessary to protect the casing and tube from rim cuts. Special glider tires and hubs are now on the market which are lighter and much less expensive than the Airwheel installation.

Two 12 x 3-in. tail wheels mounted on a short axle have been used to adapt a glider with a wooden skid for automobile towing. The axle projects through a vertical slot in the skid and is wrapped with shock cord to reduce the landing impact.

The ground angle should not approach the stalling angle as it does on airplanes. Because of burbling, the ailerons will not be effective at these high angles, and lateral control, which is essential with a single wheel, cannot be maintained until the tail is raised. If the ground angle does not exceed 12 or 13 deg. it will be unnecessary to raise the tail. This will permit mounting the wheel well forward to prevent nosing over. The low ground-angle also assures ample flying-speed at the take-off. Landing is best accomplished well above the stalling speed, therefore a large ground angle is not at all necessary. A large ground-angle also makes a glider hard to handle on the ground on a windy day. If it is left unattended, as sometimes happens, a gust of wind is likely to pick it up and lay it over on its back. We have even had one picked up slightly with a light pilot occupying the seat.

A tail-skid is, of course, necessary with a wheel. This should be kept forward to reduce fuselage stresses and should be well supported laterally.

Types of Fuselage Construction

The principal considerations in the design of a fuselage are ease of construction, transportation and assembly. The single-truss type which is braced laterally and torsionally by wires from the tail-post to the rear-strut points of the wings is the easiest to build and transport. It is, however, somewhat less convenient to set up than other types because the rigging of four wires is necessary.

Another type that requires only two tail brace-wires is very popular. It consists of four longitudinals that form a horizontal wedge at the tail. The two upper longitudinals converge at the rear-spar butt-fitting and the two lower ones at the rear of the skid. The tail section is detachable at these points. The cross member which forms the point of the wedge serves as a rear-stabilizer spar, the stabilizer being mounted permanently between the top longitudinals. The bottom longitudinals may be hinged at the rear so that they can be folded up against the top longitudinals for transportation. With this arrangement it is not necessary to dismount the empennage.

Rigidly braced fuselages that require no wire braces are very desirable, because no rigging is required in setting them up. They have not gained favor among amateur constructors because of their complicated construction, but are produced very satisfactorily commercially.

In the design of the front portion of the fuselage, the mounting of the wings and the safety of the pilot must be taken into account. If the wing is mounted by wires or cables, a cabane must be provided to support the landing wires. When wood construction is used, members near the pilot that are likely to break

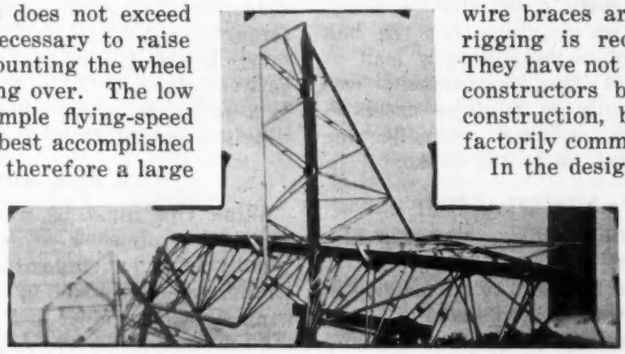


FIG. 7—AN EMPENNAGE HAVING TRUSS-TYPE MOVABLE SURFACES

Triangulated Ribs Used in This Design by the University of Detroit Glider Club Are Stiffer than Spars of the Same Weight

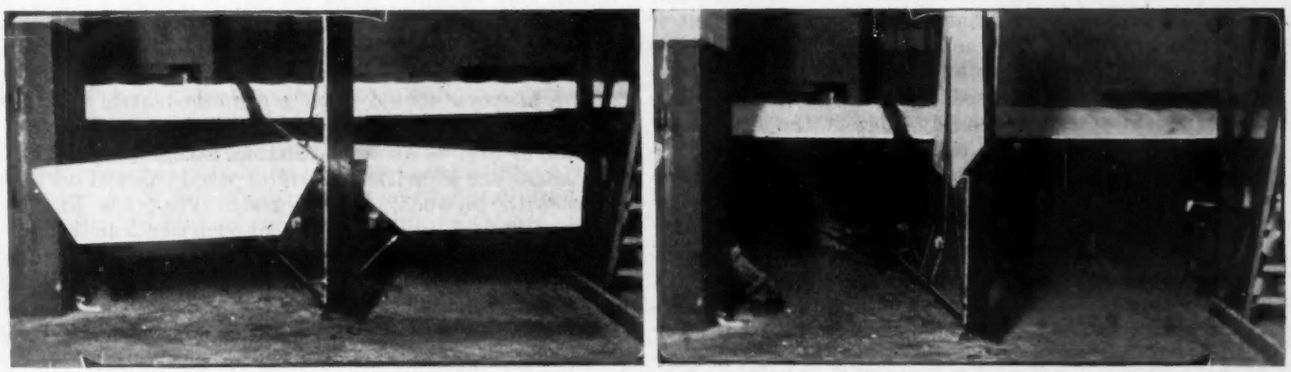


FIG. 8—FOLDING HORIZONTAL TAIL TO FACILITATE TRANSPORTATION OF THE GLIDER

The Two Halves of the Stabilizer Are Hinged to the Top Longitudinal, and a Single Elevator Horn, Mounted on the Same Longitudinal, Is Arranged So that Each Half of the Elevator, together with Its Half of the Stabilizer, Can Be Folded up against the Fin and Rudder

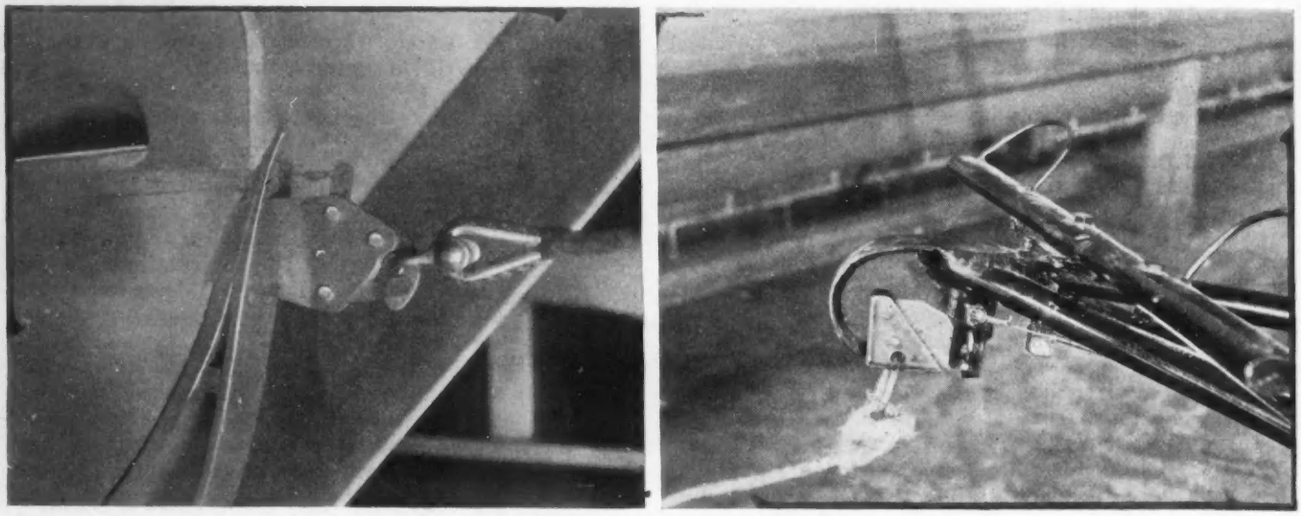


FIG. 9—TWO TYPES OF AUTOMOBILE-TOW RELEASE

That to the Left Is Designed To Release the Tow Rope upon Pressure on Either the Hook or the Retaining Prong Underneath. The Device to the Right Requires Attachment to the Rope of a Special Part, Which Is Sometimes Damaged When Dropped on Concrete or May Become Lost

in a crash should be wrapped with fabric and doped to prevent injury from splinters. Provision for a substantial safety-belt anchorage must also be made. The Department of Commerce requires that the belt and anchorage be capable of withstanding a load of 850 lb. The importance of this requirement was tragically demonstrated recently in a glider crash in which the pilot's skull was fractured when he was pitched out after the safety-belt fastening broke.

Wing Design Follows Airplane Practice

The wing construction closely follows standard airplane practice, as can be seen in Fig. 6, except that it has been found much simpler to glue the fabric to the wing structure instead of sewing and tacking. Ordinary casein glue is used for this purpose, and if the work is carefully done good results will be obtained.

Wings are always made in two sections to facilitate transportation. A rectangular plan form with either straight or curved tips is used. The aspect ratio is usually about 7.

Simplicity and economy dictate solid rectangular spars. If possible, the front spar is located so that it will attach directly to the vertical fuselage-member immediately back of the pilot. If a rigid leading edge of plywood or dural is used, however, it will be more economical to cover the leading edge if the front spar be kept forward. In this case it will have to be supported by a bending member or the landing-wire cabane structure. Location of the front spar may vary from 5 to 15 per cent of the chord. The rear spar usually is placed at about 75 per cent of the chord so that the aileron can be hinged directly to it.

Single-drag trussing consisting of square spruce drag-struts with wire cross-bracing is generally used. For this reason it is well to provide a rigid leading edge of either plywood or dural for torsional rigidity from the strut point out. Plywood is a little more expensive but is to be preferred because fabric cannot be glued to dural. Plywood 3/64 or 1/16 in. thick is satisfactory, or dural about 0.014 in. thick may be used.

The conventional trussed type of rib has so far been used almost entirely. Ribs of $\frac{1}{4}$ x $\frac{1}{4}$-in. cap strip and diagonals using single-plywood gussets have ample strength, but for gluing fabric greater width is necessary. Double ribs of the same material, with the gussets between the strips, may be used, or single ribs of $\frac{1}{4}$ x $\frac{3}{8}$-in. strips will do. The latter are easier to build. Ribs are spaced from 14 to 18 in. apart.

Wing Tips, Ailerons and Bracing

Wing tips must be protected against bad landings. A 1/16-in. plywood covering on the under surface is usually sufficient unless the tips tend to rest mostly on the rear spar when on the ground. In this case small wing-skids, as shown in Fig. 6, are advisable to protect the ailerons. The tips may be cut off straight without tapering. The improved appearance and performance of curved and tapered tips, however, justifies the extra work required to build them.

A good grade of lightweight cambric or unbleached cotton serves very well for covering. The cambric is lighter and requires less dope but is not as durable as unbleached cotton. Two or three coats of semi-pigmented dope sanded between coats makes a good finish, although some prefer to use clear dope and lacquer.

The ailerons should have a combined area of about 12.5 per cent of the wing area. Their construction is similar to that of airplane ailerons except that the control horns are sometimes made of wood covered on both sides with plywood. The trussed type (see Fig. 6) commonly used in steel-tube construction can be fabricated from wood with little difficulty. A very light spar of $\frac{1}{4}$ or 3/8-in.-thick spruce may be used and the whole assembly will be very light and rigid.

The completed wing, covered and doped, should have a specific weight of 0.600 to 0.625 lb. per sq. ft.

German influence is perhaps responsible for the general use of wires instead of struts for supporting the wings. Struts are somewhat heavier and offer slightly more wind resistance, neither of which is of much consequence in a primary glider. If welding facilities are

available, there is not much difference in the amount of work of installation of 10 wires and 10 turnbuckles as compared with 4 lift struts, 2 wires and 2 turnbuckles. It is to be noted that, since the fuselage of the Zoegling has no torsional rigidity in itself, some bracing is required to make the front and rear lift-trusses deflect together. Two wires, one on either side of the ship, running diagonally between the front and rear lift wires or struts are sufficient for this purpose. With a rigid fuselage, these may be omitted.

The difficulty of setting up and rigging a glider is appreciably decreased by the use of struts. Once they have been given their correct length in the shop, the only rigging necessary on the field when a non-rigid fuselage is used, is the adjustment of the two diagonal wires. No rigging is required with a rigid fuselage.

Turnbuckles have a tendency to turn hard after a little time in service and often have to be replaced. For this reason it is advisable to avoid their use as much as possible where they must be taken apart or slackened for dismounting. Another objection to the use of wire bracing is the tendency of wires to become loose in use. This is especially true of the landing wires, which are often subjected to high stresses because of the inefficient angle at which they must work. Failures in the landing wires are also frequent. Often the entire adjustment of turnbuckles is used up because of stretching of the wires, and the wires must be replaced.

It will be found much more convenient for transportation purposes to make all wing brace-wires detachable at the wing. Loose wires are much more easily tied to the fuselage than to the wing, and many patches in the wing fabric will be avoided if this precaution is observed.

Movable Tail-Surfaces and Controls

Fixed tail-surfaces are seldom used in soaring machines. Primary gliders usually carry a fin and stabilizer for stability and structural simplicity. Rudder control is more difficult to obtain than longitudinal control because of the relatively large moment of inertia about the vertical axis as compared with the moment of inertia about the lateral axis. A vertical tail-area of about 9 to 12 per cent of the wing area is necessary. The rudder should be 55 to 65 per cent of the total vertical area.

A horizontal tail-area of about 15 per cent of the wing area gives good longitudinal control. Of this, the movable surfaces should be about 60 per cent of the total.

The shape of the tail surfaces is usually governed by structural considerations. Rectangular and triangular fixed surfaces are most commonly used. When a single-truss fuselage is used, the last bay is sometimes covered to serve as a fin. Construction of the stabilizer may be similar to that of the wing, using two spars, or the stabilizer may be made triangular, in which case the front spar usually is shaped into a leading-edge former.

The movable surfaces may depend on their spars for torsional strength or the ribs may be triangulated, as in the aileron, so that they will transmit torsional loads. Triangulated ribs, as shown in Fig. 7, are much stiffer than spars for the same weight and are just about as easily constructed.

The vertical and horizontal surfaces should be separately removable from the fuselage to conserve space in transportation and to simplify repairs. It may be necessary only to remove the horizontal tail for transportation, leaving the fin and rudder attached to the fuselage. This is best accomplished by making the fin and rudder of cantilever type and supporting the stabilizer with struts.

The assembly and mounting of the tail group is a troublesome detail of transportation and opportunity exists for much improvement along this line. At present the University of Detroit Glider Club is experimenting with a folding horizontal tail, shown in Fig. 8, which obviates the necessity of removing any of the tail surfaces or control wires. The stabilizer is built in two halves each of which is hinged to the top longitudinal. A single elevator horn is also mounted on the top longitudinal and so arranged that each half of the elevator, together with its half of the stabilizer, can be revolved upward against the fin and rudder, where a simple clip locks it in place. The only operation required is the removal of a clevis pin from each of the stabilizer struts. If this arrangement proves satisfactory it will be well worth the extra work necessary to produce it.

Provisions for Launching

For shock-cord flights a simple hook on the nose of the skid, as in Fig. 5, is all that is required for launching. This hook is designed so that the ring in the shock cord will drop out when the tension is relieved after the take-off. A backward slope of 30 to 40 deg. to the vertical on the inside face of the hook is satisfactory. Too slight an angle will cause the ring to drop out before the full energy in the shock cord has been expended. If too great an angle is used, the nose of this ship will be pulled down before the ring drops out.

Some means of holding the tail while the shock cord is being stretched is necessary. Usually a rope is tied to the fuselage near the tail for part of the ground crew to hold. If stabilizer struts are used they may serve as hand-holds, provided they have sufficient strength.

Mechanical releases have also been successfully used for this purpose. Such a release may be operated by a member of the ground crew standing to the rear end of the glider or it may be operated by the pilot. A stake or an automobile may be used for an anchorage. The use of a mechanical release makes more of the ground crew available for pulling the shock cord, and when operated by the pilot gives more exact control of the time of release, as verbal signals are sometimes confused.

For automobile towing the problem is a little more complex. A mechanism such as those in Fig. 9, that will enable the pilot to release the glider at will from the tow rope while in the air, is necessary. As the safety of the automobile-tow flight depends to a great extent on the reliability of this release, great care should be taken in its design. An important point that may be overlooked in designing an automobile-tow release is a provision for dropping a broken tow-rope. Rope wears rapidly from being dragged on the ground and it will often be weakened to the extent that a break may occur in flight. Air forces on the rope cause it to trail behind the glider and pull backward on the release mechanism, which, if not properly designed, may not release. The danger of snagging a fence or a stake with a rope attached to the nose of a glider is serious and should be guarded against by as-

suring that the release will operate with a back pull on the rope.

A very convenient method of operating the release is by an automobile choke-wire, as in Fig. 5. This may be attached to the side of the seat, where it can be easily reached by the pilot, or, if the mechanism requires only a slight force for its operation, the choke wire may be run up through the control stick and be operated by thumb pressure on top of the stick.

While automobile towing provides good flight-training and excellent sport, it does not fulfill the ultimate end of gliding. The ambition of most glider enthusiasts is to soar. Soaring training can be obtained only on hilly terrain, where the shock cord is the logical means of launching.

Most contest events are for shock-cord flights. The present rules of the National Glider Association specify that all flights for licenses be made by shock cord. Therefore there are generally many occasions for shock-cord flights, and in contests it is sometimes necessary to make a quick change from automobile towing to shock-cord equipment or vice-versa. For this reason it is well to make the automobile-tow release easily convertible into a shock-cord hook.

Design Loads and Load Factors

An elaborate stress analysis is not necessary for the design of an airworthy glider unless an approved-type certificate is sought. The main elements of the structure should, of course, be investigated, but such computations are very simple provided the magnitudes of the loads are known. Very few data on glider stresses are available at present and, until such time as more research is done on the subject, the procedure as outlined in the Light Aircraft section of the Department of Commerce bulletin on Airworthiness Requirements is about the only reliable source of such information.

While some load factors are arbitrarily specified in these requirements, the determination of wing loads requires the plotting of a velocity diagram. This is a laborious procedure that one would hardly expect to follow in designing a privately owned glider.

Through the courtesy of the Gliders, Inc., division of the Detroit Aircraft Corp., which has recently completed the stress analysis for an approved-type certificate on its primary glider, the information which was gained in the plotting of this diagram has been made available for the purposes of this paper. For the foremost center-of-pressure location of the airfoil, which corresponds to the high-angle-of-attack condition, the load factor was found to be 4.15. For the maximum velocity in a gliding path of 1 in 6, which is a design condition of the Airworthiness Requirements, the factor was 6.5. For this latter condition the velocity along the flight path must be known in order to determine the center-of-pressure location. The computed speed of the Gliders, Inc., primary glider is 43 m.p.h.

The Department of Commerce requires that the horizontal tail be capable of supporting a load sufficient to balance the wing reactions with a margin of safety of 30 per cent. Gliders, Inc., found that this load did not exceed the specified minimum average loading of 6 lb. per sq. ft.

These results will not, of course, be exactly applicable to all primary gliders but they are an indication of design wing and tail loads as required by the Department of Commerce. The other requirements are self-explanatory and the designer will do well to follow them. It will be found in most cases that the handling and landing conditions rather than flight stresses will be critical.

Provisions for Transportation

This paper would hardly be complete without a word about transportation facilities.

Every club should have at least one trailer suitable for transporting its gliders and equipment. The trailer need not be elaborate; a framework supported on a pair of old automobile wheels will be sufficient. The wings can be stood on their leading edges in padded recesses and clamped in place by padded wood-clamps. To prevent unnecessary racking of the wing structure and wearing of the fabric, the trailer should be braced so that it will not deflect excessively, especially in torsion, or else the wings should be suspended so that they will not be affected by any such deflection. This is an important precaution for traveling over rough roads. The center of gravity should be kept as low as possible to prevent upsetting. A brisk side-wind striking the wing surfaces can easily upset a trailer on a turn.

Each piece of the equipment should have a convenient positive means of attachment to the trailer. Nothing is more exasperating than to lose some important part in transit. Locking devices having no removable parts are preferable to wing-nuts and similar fastenings.

Provision should be made to carry 180 ft. of $\frac{5}{8}$-in. shock cord, 1000 ft. of $\frac{1}{4}$ or 5/16-in. rope, a toolbox and a dolly, if one is used. A reel is handy for winding in the rope, but shock cord is more easily handled in a large coil.

Driver-Training *for* Maintenance Cost-Reduction

By J. S. Lowe[1]

Transportation Meeting Paper

A service school designed to aid the inspectors and motor-vehicle drivers of his company's motorcoaches is described by the author. The men were told that their attendance at the school was compulsory, and that they would learn things that would be beneficial to them in whatever type of life endeavor they might decide to pursue. Lessons were given twice daily and drivers were required to attend at least one session each week for 20 weeks. The men attended on their own time, and previous experience was not considered. The course was given to drivers who operated their vehicles unaided.

After describing the details of the lecture form of instruction that was given, citing examples of the type of instruction, the author states the conclusions which were reached as a result of this conference method of training and analyzes the statistics which were obtained. A further outline is given as to the method whereby instructors were selected.

UPPERMOST in the minds of automotive engineers of today is the question of economy in the operation and maintenance of motor-vehicles and how the best results can be obtained. In 1926, the Northern Ohio Power & Light Co., now the Akron Transportation Co., established a service school as a part of its transportation department. The purpose of this school was to aid the inspectors and the vehicle drivers in obtaining additional information relative to the mechanisms of the company's motorcoaches. Before the school began, it was decided to cover transportation subjects and the principles of accident prevention. The men were told at the beginning that their attendance was compulsory if they expected to remain in the service, and that they would learn things which would be beneficial to them in almost any life endeavor which they might decide to pursue.

Lessons are given in the school twice daily. Operators attend at least one session each week for 20 weeks. The men attend on their own time. Previous experience is not considered. This course of training applies only to drivers who have completed their preliminary-training instructions and are operating their vehicle without assistance. In this way it is felt that the employes get their theoretical and practical training simultaneously.

The course is conducted in the form of lectures to groups of 25 drivers. After each lecture there is an open discussion and a review of previous lectures. We have not endeavored to crowd too much information into any one lecture; rather, we have gone along point by point and analyzed the engine, the gasoline, oiling, cooling and ignition systems, the carbureter, the clutch, transmission, axles, brakes, tires, wheels and fenders. Every part of the vehicle is covered in the mechanical course. Much of it is technical and consists chiefly of explanations. The points covered, however, have been pointed out briefly in naming the subjects. Charts, drawings and actual parts of a vehicle are used in the demonstration work to give students a clear understanding of the subjects. In teaching accident prevention, care is exercised in the manner of presentation, the thought being that the lectures should tie in with accidents that actually occur. Charts form an important part of this feature of the course.

Outline of the Course

The transportation course comprises operating rules, schedules, fare collections, reports, cooperation, personal appearance, personal conduct, heat and ventilation, courtesy, selling service to the public, selling the company's securities and attendant subjects. Traffic regulations and the care of passengers are made special features. On the whole, an effort is made to cover every line of training that it is thought motorcoach drivers may need, from knowing how to drive and how to care for the complete vehicle to the proper method of caring for the public. Upon completion of the course and the attainment of resulting satisfactory grades, diplomas are presented to the men.

The company does not undertake to teach the drivers about the mechanical parts of the vehicles to the extent that they can repair them while in service if trouble develops, but it does undertake to train a man to the point where he knows what every part is designed to do, what it does and how to use it.

The results of the specialized training-school have been most gratifying from the point of cooperation with the mechanical department in reducing road calls and maintenance cost, as well as decreasing complaints from our patrons and the number of accidents. As the problem in industry today is to get the whole man on the job during working hours, we have found our schooling a most successful way of obtaining the best results.

[1] General superintendent of transportation, Akron Transportation Co., Akron, Ohio.

Examples of Instruction Given

The gasoline engine constitutes a subject of considerable breadth and importance. In the engine lessons the students receive thorough instruction on the four-cycle engine which is universally used in automotive work. The two-cycle engine is also explained. The students are told that oil is as necessary to the gas engine as blood is to the human body and are shown the necessity for watching the oil gage. Cut-away parts of the engine enable the students to get a clear understanding of the cooling system and how water is forced through the system by the water pump. Other details of the engine such as timing, firing orders, valves, pistons, and the like, are also explained in detail.

In receiving instruction on the transmission gears, students are familiarized with the various gears and shown that the top or transmission-shaft gears revolve according to the speed of the rear wheels, while the lower or countershaft gears revolve according to the speed of the engine. It is quickly understood from this demonstration why it is necessary to allow the engine to slow down in shifting forward or to step the engine speed up in back shifting. The students are also instructed as to what harm can be done to the gears by improper shifting or jamming.

Development Statistics Quoted

The former city transportation system of Akron, Ohio, as it was in 1920, is shown in Fig. 1. At this time this company was operating street-car lines only. Fig. 2 shows the system in February, 1929, and illustrates the expansion due to motorcoach transportation. Table 1 shows the effect of motorcoach service on the volume of street-car revenue-passengers for the years 1922 to 1929.

Table 2 shows the motorcoach route-miles in operation, motorcoach miles operated, motorcoach revenue-passengers carried and the percentage of increase over the previous year from 1922 to 1929 inclusive. The consistent increase throughout the entire period, except a slight decrease in motorcoach route-miles operated in 1929, will be noted.

An illustration of the company's classroom is given in Fig. 3 and, in Fig. 4, the instructor had just finished a lecture in the classroom on ignition and is showing the class members the parts included in the battery distributor-system such as is used on twin coaches. The explanation in this case was centered on the distributor, showing how the breaker points work to cause a spark at the spark-plugs. The students are also shown how the current is distributed by the rotor-brush as it makes contacts with the segments in the distributor head which are connected to the respective plugs.

Students also receive instruction in the operation of the treadle used in opening and closing doors. They are shown how the small contact-fingers complete the electrical circuit when the passenger steps on the treadle. A demonstration is given to show how dirt collected beneath the treadle will prevent proper operation because the treadle could not be depressed sufficiently to make proper contact. The students are instructed to look for this defect in case rear-door trouble develops suddenly. Demonstrations are made to students to illustrate the importance of proper care of tires, this being essential to increased mileage and fewer delays on the road from tire trouble. They are instructed to see that tires are properly inflated and that no foreign objects are lodged between the dual tires. In one case of a tire that had been damaged beyond repair by a foreign object between the dual casings, drivers were told by the instructor that, had the driver removed this object, the company would have gotten

TABLE 1—EFFECT OF MOTORCOACH SERVICE UPON THE VOLUME OF STREET-CAR REVENUE-PASSENGERS

Year	Revenue-Passengers Carried		
	Total Number	Number by Motorcoach	Percentage by Motorcoach
1921	34,322,022	.....	...
1922	35,898,040	2,003,927	5.6
1923	39,421,773	4,840,968	12.3
1924	34,995,717	7,492,960	21.5
1925	39,070,768	11,856,312	30.4
1926	39,545,189	17,392,954	44.0
1927	39,557,235	19,038,134	48.2
1928	40,475,654	20,734,287	51.3
1929	40,384,075	22,433,100	55.5

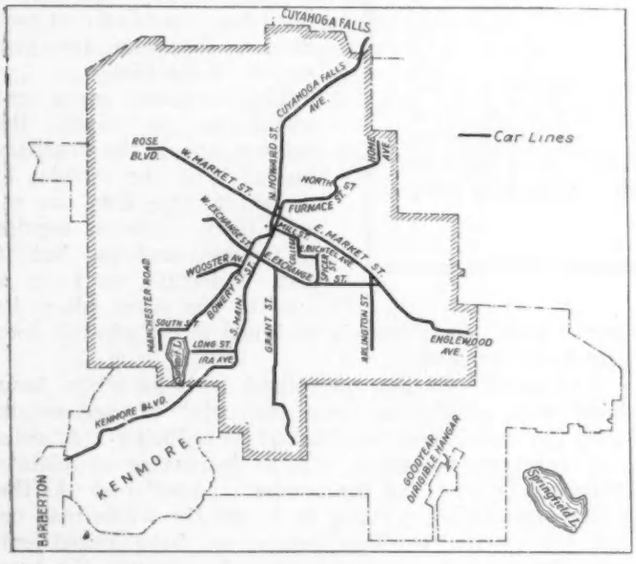


FIG. 1—AKRON TRANSPORTATION SYSTEM, 1920

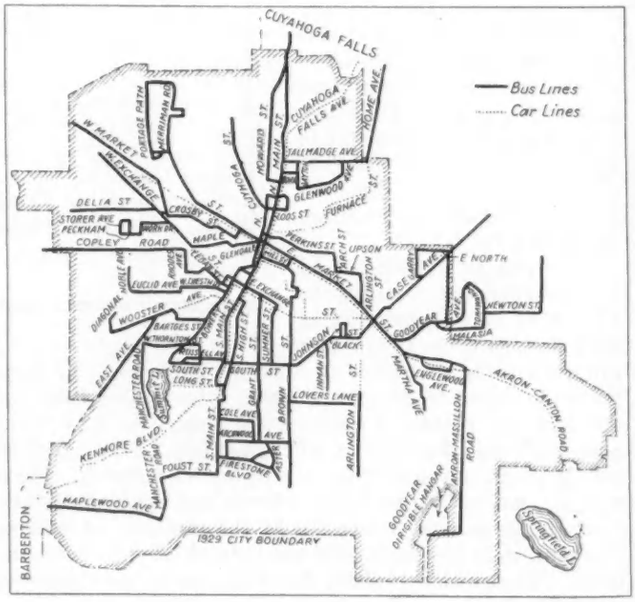


FIG. 2—AKRON TRANSPORTATION SYSTEM, FEBRUARY, 1929

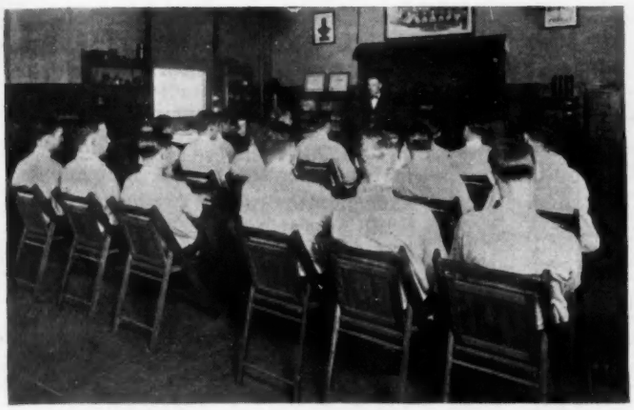


FIG. 3—DRIVERS' INSTRUCTION-SCHOOL CLASSROOM, AKRON TRANSPORTATION CO.

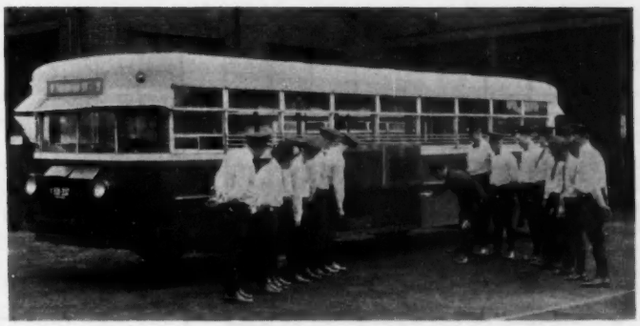


FIG. 4—DRIVERS BEING INSTRUCTED REGARDING THE BATTERY DISTRIBUTOR-SYSTEM

at least 15,000 more miles of service from the tire.

Fig. 5 illustrates the first commencement exercises of driver candidates for graduation that ever were held in this Country. It is surprising to note the keen interest the employes have taken in this training course. A diploma is awarded to each motorcoach driver who has passed the examination tests.

Data Regarding the Operators' School

In the conference method of training motorcoach drivers and street-car operators, subjects under consideration are as follows:

Quality of Information.—This involves giving sufficient information to meet the needs of the patron fully, even though this requires going beyond the customer's actual questions, and being certain that the statements are accurate. All information must be made clear and understandable and must be adapted to the ability of the particular customer to understand and remember it.

Interest in the Customer.—The men must retain a cheerful and friendly attitude, making every effort to assist in a ready and willing manner. They should make the patron feel that he is receiving the operator's undivided attention and show an unusual desire to assist the patron by asking enough intelligent questions to ascertain his exact needs.

Speech.—Drivers and other operators are instructed to speak in a pleasant low-pitched well-modulated tone, using care to avoid the unpleasantness usually associated with a sharp voice or an abrupt manner; to speak distinctly in order that the patron may have no difficulty in easily understanding everything that is said; and to choose words appropriate to the individual avoiding as much as possible incorrect pronunciation and faulty grammatical construction.

Courtesy or Politeness.—Requires the use of appropriate polite phrases, and the men are told also to perform such courteous acts as they may have opportunity to do.

Personal Appearance.—Instructions are given each man to wear neat, clean and well-fitting clothes; to keep his person presentable by being well groomed and using care to keep his hands, face and teeth well cleaned; and to have an alert bearing, avoiding unpleasant habits and manners.

Transfers and Transfer Privileges.—The men are told to issue transfers on request only; to be certain of line, time, letter, color and P.M. stub; to issue at transfer points only on pay-leave equipment; to accept emergency transfers when the occasion is justifiable; and to accept transfers at the designated transfer points only, and within the time limit punched thereon. In event of ejectment of a passenger, the driver is to secure witnesses and make out a report at the completion of the run.

Fare Collection.—An operator must make certain that the company is compensated for each and every passenger carried. He must watch the fare-box to see

TABLE 2—REPORT SHOWING MOTORCOACH DATA

Year	Motorcoach Route-Miles in Operation	Motorcoach Miles Operated	Motorcoach Revenue-Passengers Carried	Increase over the Previous Year, Per Cent
1922	2.5	426,501	.....	....
1923	16.80	4,017,803	2,003,927	....
1924	16.80	2,071,591	4,840,968	58.7
1925	49.80	3,243,762	11,856,312	59.1
1926	71.05	4,807,546	17,392,954	31.8
1927	89.20	5,125,346	19,038,134	08.7
1928	95.74	5,371,427	20,734,287	07.8
1929	92.71	5,729,188	22,433,100	08.2

FIG. 5—FIRST COMMENCEMENT EXERCISES OF THE AKRON TRANSPORTATION CO.'S MOTORCOACH-DRIVERS' SCHOOL

This Represents the First Event of Its Kind in the United States. Each Motorcoach Driver Who Passes the Final Examinations Satisfactorily Is Awarded a Diploma

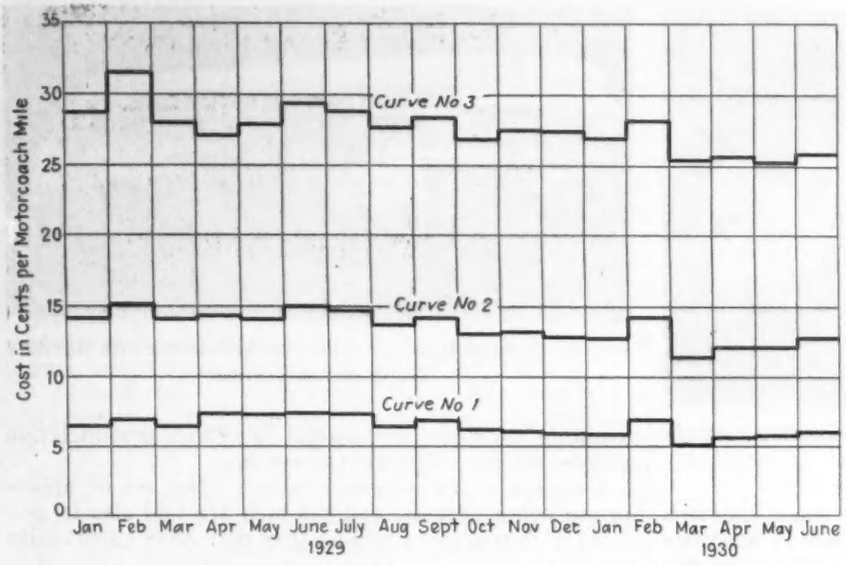


FIG. 6—CURVES SHOWING MAINTENANCE COST, CURVE 1; MAINTENANCE AND SHOP OPERATING EXPENSES, CURVE 2; AND TOTAL OPERATING COSTS, CURVE 3, OF THE AKRON CITY TRANSPORTATION CO.

that the proper fare is deposited, and keep the inspection plate clear. Further, he is told to inspect other than regular transportation tickets that may be presented to see that they are acceptable.

Accident Prevention.—This includes why life and limb must be preserved and needless destruction of property and unnecessary expenditure of money must be prevented; how this can be done by having adequate knowledge of the duties and by being alert; that "when" means at all times, whether on or off duty; and that "where" means everywhere, because the most serious accidents occur where least expected.

Operation.—Instructions are to operate in a safe and efficient manner at all times, and with due consideration to the equipment and the company's passengers; and to make evident by the good quality of the operation that courtesy and consideration for other traffic is a policy of the company.

What To Do When Accidents Occur.—Take care of the injured, notify the company and secure witnesses; help clear the scene of the accident so that traffic can move; and fill out a written report explaining all details in full at the completion of each day's work.

Statistics Given in Tables

The curves in Fig. 6 show the maintenance cost, the maintenance and shop operating expense, and the total operating-costs. The chart is self-explanatory. The training school has been of great assistance to our superintendent of equipment in establishing this reduction. This record was made with aging equipment as there had been no new motorcoaches in operation on our property since May, 1929.

In the safety lectures students are impressed with the fact that safety not only should be but *must be* their foremost consideration, and that cutting in and out of traffic and passing lines of traffic moving in the same direction has been the cause of head-on collisions with vehicles coming from the opposite direction. The students are instructed to have proper consideration for drivers of other vehicles, and not to be selfish in maintaining their rights on the public streets.

Table 3 gives an accident comparison for the years 1923 to July 31, 1930, inclusive. The total accidents increased from 5691 in 1923 to 6152 in 1926, which was our peak year in accidents. Through efficient training we have been able to reduce this total year after year, showing 1930 as having 1857 accidents for the first seven months, which reduces the monthly average from 512 in 1926 to 265 in 1930. At the same time we have increased the miles operated per accident from 2584 to 4766. During the same period we have increased the passengers carried from 11,884 to 18,641 and reduced the vehicle collisions from 3715 in 1926 to 2681 in 1929, with only 939 vehicle collisions in the first seven months of 1930. The average number of vehicle collisions per month was reduced from 309 in 1926 to 223 in 1929, and to only 134 for the first seven months of 1930. We operated 4279 miles per vehicle collision in 1926 while, in the first seven months of 1930, we operated 9426 miles. During the first seven months of 1930, as compared with 1929, an average monthly reduction of 124 accidents was made and vehicle collisions show a reduction of 89 per month.

TABLE 3—ACCIDENT COMPARISON, 1923 TO JULY 31, 1930, INCLUSIVE, NORTHERN OHIO POWER & LIGHT CO.

Year	Total Accidents	Average No. of Accidents Per Month	Miles Operated Per Accident	Passengers Carried Per Accident	No. of Vehicle Collisions	Average No. of Vehicle Collisions Per Month	Miles Operated Per Vehicle Collision	Average Cost Per Accident
1923	5,691	474	2,689	14,645	3,401	283	4,500	$61.27
1924	5,008	417	3,079	14,694	3,075	256	5,014	67.74
1925	5,596	466	2,816	13,755	3,482	290	4,527	57.15
1926	6,152	512	2,584	11,884	3,715	309	4,279	57.75
1927	5,475	456	2,878	13,218	3,203	266	4,920	58.70
1928	4,938	411	3,202	14,418	2,788	232	5,672	64.99
1929	4,670	389	3,354	14,856	2,681	223	5,839	63.35
1930[a]	1,857	265	4,766	18,641	939	134	9,426	....

[a] During the first seven months of 1930 as compared with 1929, an average monthly reduction of 124 accidents was made and the number of vehicle collisions show a reduction of 89 per month.

Table 4 gives an accident comparison, from January to July inclusive, between 1930 and 1929. Vehicle collisions were reduced by 651, or 40.9 per cent. The reduction in the total transportation accidents was 965, or 34 per cent. The accident reduction for the entire property, including the electrical industry, was 1038 or 32 per cent. The average number of miles operated per accident for the first seven months of 1930 was 4766, while the average for the first seven months of 1929 was

TABLE 4—ACCIDENT COMPARISON FROM JANUARY TO JULY INCLUSIVE, 1930 AND 1929[a]

Month	Vehicle Collisions 1930	Vehicle Collisions 1929	Total for Transportation 1930	Total for Transportation 1929	Total for Property 1930	Total for Property 1929
January	149	253	297	437	355	511
February	158	251	281	432	335	483
March	145	250	268	406	321	453
April	139	231	283	394	317	450
May	127	234	255	404	306	481
June	108	194	240	386	285	434
July	113	177	233	363	279	424
Total	939	1,590	1,857	2,822	2,198	3,236

Reduction, Vehicle Collisions	651 or 40.9 per cent
Reduction, Total Transportation Accidents	965 or 34.0 per cent
Accident Reduction, Entire Property	1,038 or 32 per cent
Total Miles Operated; first seven months—	
1930	8,851,886 Miles
1929	9,201,027 Miles
Average Miles Operated per Accident; first seven months—	
1930	4,766 Miles
1929	3,260 Miles
Increase in Miles Operated per Accident	1,506 Miles
Fatalities, Entire Property; first seven months—	
1930	6
1929	18
Decrease in Fatalities	12 or 66.6 per cent

[a] Note that 5381 accidents in 1929 cost $351,530.11. The average cost per accident was $65.32. The 1038 fewer accidents during the first 7 months of 1930, at $65.32 per accident represents a saving of $67,802.16.

only 3260, showing an increase in 1506 miles operated per accident. Fatalities for the entire property for the first seven months of 1930 were 6, as compared with fatalities for the first seven months of 1929, which were 18. This is a decrease of 12 fatalities, or 66.6 per cent. In 1929, 5381 accidents cost $351,530.11, with an average cost per accident of $65.32. There were 1038 fewer accidents for the first seven months of 1930. At $65.32 per accident, this represents a saving of $67,802.16.

Table 5 is a monthly comparison based on motorcoach miles operated. It shows the percentage of vehicle collisions per 10,000 miles by months. There is a consistent reduction in the percentage of vehicle collisions each month for the first seven months of 1930. The

TABLE 5—MONTHLY COMPARISON, BASED ON MOTORCOACH MILES OPERATED ON ALL DIVISIONS OF THE RAILWAYS DEPARTMENT, NORTHERN OHIO POWER & LIGHT CO.

Month	Per 10,000 Miles Operated—Vehicle Collisions 1929	Vehicle Collisions 1930	Total Accidents 1929	Total Accidents 1930
January	1.87	1.13	3.22	2.26
February	2.01	1.31	3.47	2.33
March	1.82	1.10	2.95	2.04
April	1.76	1.02	3.01	2.08
May	1.75	1.00	3.03	2.01
June	1.51	0.90	3.02	2.01
July	1.34	0.93	2.68	1.92
August	1.42	....	2.64	....
September	1.55	....	2.72	....
October	1.79	....	3.03	....
November	1.84	....	3.01	....
December	1.83	....	2.95	....
For the Year	1.71	....	2.93	....

table also shows a total percentage of accidents per 10,000 miles operated, making a consistent decrease in the total number of accidents per 10,000 miles.

Accident-Prevention-Department Work

A chart for each division of the operation is displayed to indicate the monthly accident record of that division as compared with the same period of the previous year. This figure is a record of the Akron city division, and a very substantial reduction in the number of accidents during the first seven months of 1930 as compared with 1929 will be noted, there being 771 fewer accidents that occurred in this division during the first seven months of the year, as shown in Fig. 7.

During 1924 the accident-prevention department inaugurated an individual accident record indicating the exact experience of our motorcoach drivers. Primarily, this record was compiled to determine who the careless men were and at the same time to indicate those who were exceptionally careful. At the close of the first year the accident records were carefully analyzed and it was discovered that a total of 35 operators had completed the year without being involved in an accident of any nature. These operators were presented with a gold emblem indicative of this accomplishment. Following the presentation of the safety medals, the safety honor-roll was created. This is conspicuously placed in the assembly room of each division and, at present, it

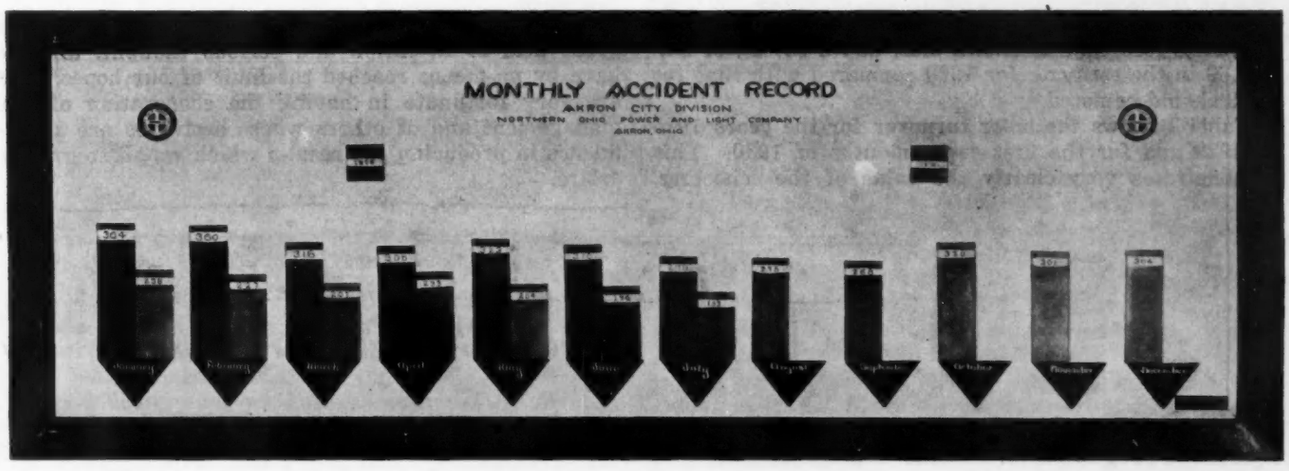


FIG. 7—MONTHLY ACCIDENT RECORD SHOWING SUBSTANTIAL ACCIDENT REDUCTION FOR 7 MONTHS OF 1930 AS COMPARED WITH THE SAME PERIOD OF 1929

TABLE 6—DISCIPLINE COMPARISON, FOR THE CITY DIVISION OF AKRON FOR THE YEARS 1928 AND 1929, WITH AN ESTIMATE FOR 1930

	Year	Number	Year	Number	Decrease	Total Decrease
Employes Cautioned	1928	8,724	1929	3,120	5,604	
	1929	3,120	1930 (Estimate)	2,424	696	6,300
Number of Days Suspended	1928	7,440	1929	4,008	3,432	
	1929	4,008	1930 (Estimate)	3,240	768	4,200
Cost to Employes	1928	$42,408.00	1929	$22,845.60	$19,562.40	
	1929	22,845.60	1930 (Estimate)	18,468.00	4,377.60	$23,940.00

TABLE 7 — LABOR TURNOVER OF THE NORTHERN OHIO POWER & LIGHT CO., FOR THE YEARS 1925, 1929 AND 7 MONTHS OF 1930

Year	Per Cent
1925	17.00
1926	11.00
1927	4.65
1928	3.95
1929	3.62
1930 (7 months)	2.10

displays the names of 322 men who have operated motorcoaches for a period of from 1 to 5 years without an accidental occurrence. These men, to the number of 225, have completed their first year; 60 their second; 26, their third; 8, their fourth; and 3 have operated entirely free from accidents during the last five years. The number of names appearing on the honor roll has steadily increased from 35 at the close of the first year to 124 during the year ending May 1, 1930.

Disciplinary Statistics and Labor Turnover

Table 6 gives a discipline comparison for the Akron City division for 1928 and 1929, and an estimate based on the first seven months of operation for 1930. It covers both street-car and motorcoach operation. In 1928, our employes were cautioned for various violations of our rules 8724 times, while in 1929 it only became necessary to caution them 3120 times, making a decrease of 5604 cautions. The 1930 estimate based on the first seven months of operation and compared with 1929, shows a decrease of 696 cautions. The table also shows that we do not think it possible to operate a transportation company without discipline. In the year 1928, employes were suspended 7440 days. In 1929, they were suspended 4008 days, or a decrease of 3432 days. There is a considerable decrease in 1930, as compared with 1929.

In 1928 as shown in the table, it cost the suspended men 7440 days $42,408.00, and in 1929 it cost the men who lost 4008 days $22,845.60. This demonstrates very clearly that the employe, generally speaking, is willing to do just as one would have him do if he thoroughly understands the necessity of so doing. A saving of $19,562.40 in one year to the men who were required to lose time is shown also, and a saving of $4,377.60 in the estimate for 1930 compared with that for 1929 should be noted.

Table 7 shows the labor turnover for the years 1925 to 1929 and for the first seven months of 1930. This demonstrates very clearly the value of the schooling, which creates a better understanding between the men and the management. It also is indicative of loyalty and contentment; in fact, it is a record that we can well be proud of in an industrial community, as the labor turnover in the larger industries of Akron averages 60 per cent.

Selection of Instructors

The selection of a suitable instructor is one of the most difficult tasks in establishing and conducting a school, as the instructor should be selected from the rank and file of drivers if possible. He should, of course, be a man of the highest type in the organization, of pleasing personality and well liked by his fellow employes. He must also possess a successful record as an operator with respect to caring for equipment, courtesy, and cooperation, and must have an excellent accident-prevention record. He should have a pleasing voice and impressive delivery. We happen to have this particular type of instructor in our organization, whose previous training well qualifies him to fill the position and who has had considerable training in public speaking which qualifies him as an efficient instructor.

The illustrations have indicated some of the results obtained through the extensive training given our motorcoach drivers. The cost of this training is also interesting. A room not in use was equipped at our principal garage with various automotive parts which were not serviceable; that is, with equipment damaged by improper use. As this room was a part of the main garage, the cost of lighting and heating was very nominal; in fact, the only cost worthy of mention is the salary of the instructor, which is the same as that of a dispatcher.

This subject of driver training has been given a great deal of attention and serious thought, and we have by no means reached the limit of our hopes. We are very fortunate in having the cooperation of our management and of others whose activities are an influence in producing the results which we all so greatly desire.

Aircraft-Engine Design *for* Low Cost

18th National Aeronautic Meeting Paper

By Edward D. Herrick[1]

AIRPLANES were used almost exclusively for military and training purposes up to about four years ago, and the Government was practically the only sales outlet. It followed necessarily that, during that period in which the airplane was proved to be a sound means of rapid transportation, engines and airplanes were designed with military rather than commercial requirements in mind. This development of the aircraft industry had been dependent largely on the resources and efforts of the Government in conjunction with those of several manufacturers, and their combined efforts have resulted in a fund of knowledge on airplane and engine characteristics which is very valuable to the manufacturer today.

I wish to pay a tribute to the Government and to those pioneer manufacturers for carrying on under very adverse conditions and for bringing the aircraft industry to the point where it is today. The Army, the Navy and the Department of Commerce have done a great work in bringing aircraft engines to their present status, by their cooperation with the manufacturers and by means of their large experimental resources. This work has been beneficial in specific instances, and still more in the wealth of data that have accrued from their work, which has been available and of tremendous value to all manufacturers. The maintenance data, which these departments have amassed from a large number of engines, have been of great value, because failures that might occur in production were brought to light. This information could not have been obtained had the engines been distributed to a great many users.

One difficulty that we have encountered in virtually all fields in which we are engaged is that of securing accurate information from the field. It seems that the operator who encounters trouble usually feels that it is necessary to magnify the trouble at least three times in order to get any action from the factory. Consequently, every report that comes in is taken with a grain of salt.

Today there are three fields for aircraft engines: the military, with its stringent requirements as to reliability, light weight, high ceiling and economy; the specialized transport field, with its requirements as to reliability, light weight and economy; and the broad commercial field, with its requirements as to reliability, light weight, economy, and cost. The industry has been in a state of flux, since it has broadened into the commercial field, because the private owner, who undoubtedly represents the largest potential market, is not in a position to know what he wants. However, following the already proved lines, we do know that he wants reliability, comfort, economy and longevity.

Tribute is paid to the three Government departments and early manufacturers who were responsible for the development of airplanes to the point where they became a commercial possibility. One of their important services was the collection of a mass of service data.

Cost is vital in engines for commercial service. The selection of an engine type that is inherently light makes a reasonably light engine possible without extremely expensive weight-saving in details.

Consideration of the availability of materials and close cooperation with both the production department and outside suppliers of parts are points stressed in the initial design. The development work included tests at points selected for extremes of climate and embodied detail changes that were suggested for economy. One suggested source of possible economy is the elimination of duplicating inspection of purchased parts.

An enumeration is made of several advantages resulting from establishing an aircraft-engine plant as an adjunct to an existing automobile-engine plant rather than as an independent enterprise.

Cost Vital in Commercial Engines

In making an entrance into the aircraft-engine industry, the company with which I am connected decided, after a very careful study, to go into the commercial field. It was realized that cost is a very vital factor in this field, and that every line of approach would have to be explored to produce an engine economically. From the time this program was inaugurated, cost has been given due consideration at every step.

The first decision to be made was, what size shall the engine be? It was decided that an engine in the 200 to 225-hp. class would be the size required for the field in which this engine was to be used.

The type of engine decided upon was the air-cooled radial, as it has inherently the lowest weight per horsepower and had already met with public acceptance. It is logical to assume that an engine having cylinders disposed radially about a one-throw crankshaft can be made at less cost than an engine which has a multiplicity of crank throws and great length. The selec-

[1] M.S.A.E.—Chief engineer, Lycoming Mfg. Co.

tion of the type giving the lowest weight per horsepower permitted the greatest latitude in designing to get a reasonable weight per horsepower at a reasonable cost. While light weight does not always mean low cost, it tends toward low cost if the materials are the same. This indicates that the radial type of engine is inherently cheaper than other types to build.

From the moment the displacement of an engine is decided upon, its design is a series of compromises. The one point about an aircraft engine that cannot be compromised is reliability. The relative importance of other requirements—such as power:weight ratio, cost and ease of maintenance—are matters of judgment.

It was anticipated that privately owned airplanes would constitute the major volume in the field into which we were entering. The comfort of the occupants was therefore recognized to be of vital importance, as it was definitely found to be during the course of automobile development. This necessitated a very careful study of design to make sure that the desired requisites of quietness and smoothness should be inherent in the design.

Type Is Main Chance in Weight Saving

Because a type of engine was adopted which inherently gives light weight per horsepower, it was possible to reduce the stresses in parts that normally are highly stressed without making the total engine weight objectionable and to eliminate some extremely difficult machine operations. Careful analysis was made by balancing the machining cost against the weight of the part, in order to keep within the weight limitations and yet design the parts so they could be manufactured economically. Close contact was maintained with the manufacturing departments to avoid the necessity of special machinery and unduly expensive machining operations. A number of vendors who had a wealth of experience in the manufacture of certain aircraft-engine parts were consulted during the course of the design work, so that ease of production was given careful consideration in the design of parts.

Careful selection of tried and proved units was made in the initial design. A careful study was made in arranging these units to make them accessible for inspection and service in the field as well as to effect the drives and attachments at the minimum cost.

The selection of materials also involved careful study of both the physical properties of the materials selected and their availability at the various sources. The following is a striking example of what happened when availability was not sufficiently considered: A material was specified with the assumption that it could be obtained at once; but in reality it was not obtainable without a special run at the mill, which took some 10 weeks.

Reducing the number of materials used makes it possible to purchase in larger quantities, which is a very vital factor in obtaining special materials. It also simplifies heat-treating equipment, inspection and metallurgical work.

Experimental Stage of Development

After the experimental design work had been completed, it was necessary to go into an extensive program of experimental and development work. This work was carried on at the factory, both in the laboratory and in flight; and also points were found where extreme climatic conditions prevailed, and tests were conducted there to make this work complete. During this testing period, weaknesses of design were corrected and new ideas were tried in an effort to reduce the cost of the parts as originally designed. This development work was continued until it was felt that the design was in such state that the engine could be manufactured economically.

During the development period it was found that a number of manufacturers were equipped to make parts, as they had already been doing work of a similar nature for other manufacturers and were considered reliable sources of supply. It was found also that, because they were specialists of these particular parts, they could manufacture them more cheaply than the parts could be manufactured in our own plant. In such instances the necessity for the purchase of machine-tools for these particular parts obviously is eliminated.

The knowledge of these parts makers was in many instances of great help to us in designing specific parts for economical production, as well as in the selection of suitable materials that were obtainable within a reasonable time. This assistance as to the availability of various materials is of the greatest importance, as it has been found in several instances that the material originally specified, while suitable from a design standpoint, could not be readily procured. Contact with the parts makers is also of help in coming to an understanding in regard to the finish of parts and other matters that may be somewhat indefinite on the drawings.

Advantages of Side-Line Beginning

Bringing the aircraft division under the scope of an existing company, which had already manufactured a similar line, such as automobile engines, made it possible to utilize to a large extent the administrative organization and, by a slight increase, the receiving, shipping and service departments, which means that the aeronautic engine is burdened with appreciably less overhead than it would be otherwise.

Recognition is given to the essential difference between the manufacture of aircraft and automobile engines. However, certain phases of mass production are comparable, and these we have recognized and utilized to advantage.

Utilizing the purchasing power of an organization which has already had experience in a high-production field in parts similar to those used in aircraft engines has been a decided advantage. Quantity is well recognized to be a very vital factor in the cost of manufacturing any commodity. This is particularly true in the purchase of parts that can be made in high production from permanent-mold castings, forgings or stampings. Purchasing in larger quantities, the number of machine-tool setups is minimized, and more elaborate tooling can be used. These bring the manufacture of aircraft engines, and particularly accessories, more nearly to the basis of automobile-engine parts.

Other objectives of the close contact maintained with the production departments during the designing were to eliminate unnecessarily close tolerances, to simplify routing and to reduce the number of operations. Two considerations guided in the selection of equipment for the manufacture of parts in our own factory: First, recognition of the lack of permanence in the present state of aviation with regard to engine requirements. This makes necessary the use of machine-

tools of a somewhat universal nature, with removable special fixtures, rather than of special-purpose machines. Second, previous experience in other lines of endeavor indicated that the use of oversize equipment was desirable to obtain the maximum trueness and good finish if speed were to be attained.

There is an essential difference in requirements between the workmen on aircraft engines and those on automobile engines, primarily because of the high cost of the material on which the former work, in that considerably more money is involved when a part is spoiled. Also, more skilled mechanics are required on aircraft engines because elaborate jigs and fixtures, such as are provided for automobile engines, are not used. However, there is no reason why a piece-rate system cannot be used on aircraft engines; and it should function as well as it does in other lines of work if recognition is given to the importance of the work.

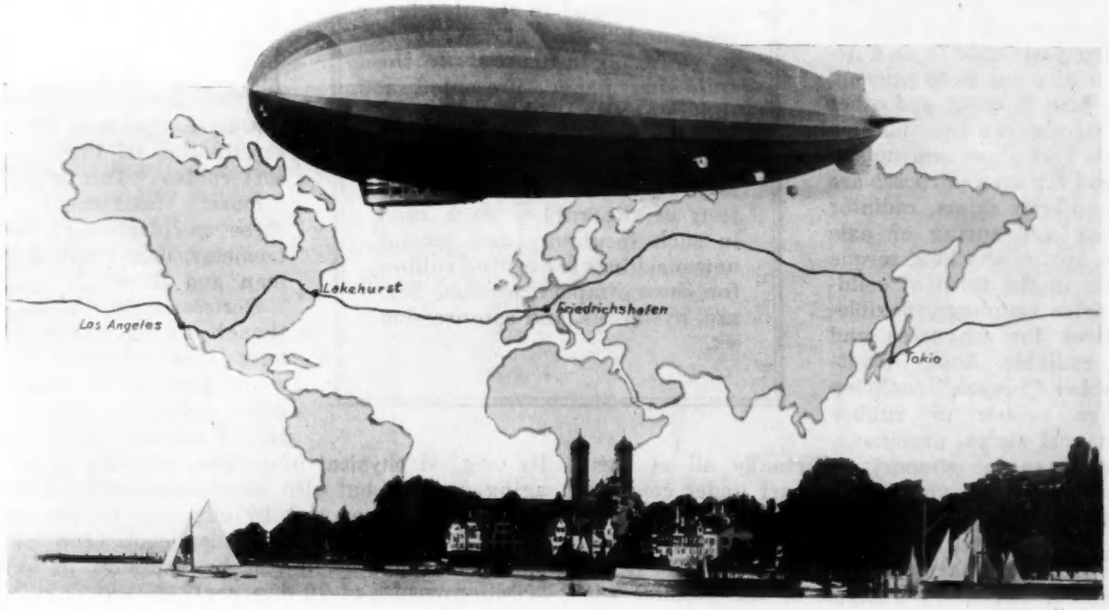
Can Duplication of Inspection Be Eliminated?

Very rigid inspection must be maintained, from the raw material to the completed piece, the most rigid inspection being concentrated on highly stressed parts. It has been found economical to inspect thoroughly the rough materials and to follow with inspections throughout the sequence of operations, so that any part in which defects are found can be scrapped with the least possible amount of machine work. Someone has suggested that there should be a fixed numerical ratio between inspectors and machine operators; but I do not know what this should be or how any definite ratio could be arrived at, because conditions differ in various factories.

In our factory, as well as in other factories, there now is a great deal of duplication of inspection on parts that are purchased. I feel that this is wasteful. I believe that it is feasible for vendors to be found who are wholly reliable, who realize their moral obligations and are willing to furnish affidavits that the parts they manufacture meet the specifications in every respect. One inspection or the other should be eliminated; preferably, inspection should be maintained at the source, because unnecessary transportation charges would be avoided in the event of rejection. Many engine manufacturers will corroborate the statement that vendors, realizing that parts will be inspected at their destination, tend to be lax in their judgment and to assume that parts which are not suitable will be rejected at their destination. This is a chance often taken.

I do not mean by the foregoing that all inspection of vendors' materials should be eliminated; I refer to the 100-per cent inspection, which often involves very expensive and elaborate inspection-judgment.

Cost reduction on aircraft engines involves no magic or secret formula; rather, it results from the application of the general principles of intelligent cooperation and coordination of effort, both with outside sources of supply and within the engine-builder's plant, coupled with hard work.



Automotive Research

Evaluation Tests for Rubber Vibration-Insulators

By Franz D. Abbott[1]

GRADUALLY the use of rubber parts in motorcars and airplanes has been increasing until, almost overnight it seems, automotive engineers awakened to the fact that vulcanized rubber, in its many possible forms, possesses remarkable properties that make it an outstanding engineering material of the day. Chief among these properties that hitherto had been neglected, except by a few pioneering souls, is its exceptional ability to intercept vibrations varying from almost imperceptible impulses to impacts and forces of great magnitude, and either to absorb these completely or change them into unobjectionable forms. Making use of this property of absorbing and transforming energy has not only called forth the inventive genius of the automotive engineer and the chemically creative genius of the research and compound chemists, but has placed upon the testing engineer an obligation even more exacting in many cases. The testing engineer is constantly confronted with the task of developing new tests to simulate service conditions as far as practicable and to give the required information in the minimum possible time.

The unprecedented demand of car manufacturers within the last three years for automotive rubber parts of an almost endless variety of shapes and sizes has evidently been based upon a sudden realization of the remarkable ability of rubber to absorb completely, or change into unobjectionable forms, all manner of vibrations. The manufacturers of these rubber parts have not only kept pace with these demands but more often have pioneered in the development and testing of new types of vibration insulators. In the following paper, presented at the Feb. 10, 1930, meeting of the Cleveland Section, the author describes the most recent laboratory and semi-service tests of the rubber stock used in such insulators and several new machines for testing rubber for shear, impact, torsion, flexure, hysteresis, and compression set.

The purpose of virtually all the rubber parts used in an automobile or airplane is to prevent, not only body squeaks and other noises, but also the transmission of engine vibrations and noises. Parts used for such purposes are fender and body shims, radiator pads, door and spring or axle bumpers, spring shackles, torque insulators in the form of solid-rubber drive couplings, flexible-hose drives for magnetos and pumps, radiator hose, silent-block rubber "hinges," cushions of sponge rubber or rubber foam, channel strips, grommets, and, finally, engine supports. Virtually all of these are assembled either wholly or in part under compression, yet their life, particularly in certain individual cases, depends also on their resistance to shear, impact, and, less often, ordinary tensile stresses.

A complete laboratory analysis of the possible service life of a rubber part will require information along the following lines. Only a part of these, however, are ordinarily necessary in most cases.

Tensile Strength.—This test is quite important for stock-comparison purposes when developing new stocks, but investigators have repeatedly shown that tensile strength is not necessarily an indication of high quality as a shock-absorbing material. The test is often performed on test strips cut from the parts themselves, or, in the case of the new vertical type of engine support in which the rubber is bonded under pressure during vulcanization to the metal, tensile tests are made on the support itself. This latter test is desirable mainly for the purpose of determining the strength of this metal-rubber union.

Stresses at Various Elongations.—These moduli data are, to a considerable extent, a measure of the stiffness of the stock. They are determined instead of the modulus of elasticity, as in metals and other engineering materials. It is important to note that rubber is the only material possessing a concrete value of Young's modulus.

Hardness (Penetration).—Although not a true measure of the actual stiffness of a stock, penetration data obtained in the proper way, by a well-constructed instrument, are very valuable in classifying rubber parts. Recently the Committee on Rubber Products (D-11 Subcommittee 17) of the American Society for Testing Materials formulated a tentative standard for the determination of the hardness of soft rubber. The first accurate, compact instrument meeting these specifications is the penetrometer, described[2] by Zimmerman and Brown.

Resistance to Aging. — Even though a given rubber part may have ideal physical properties when new, it is necessary, in most cases, to determine the ability of that stock to retain its original physical properties, not only after natural aging periods, but also after such artificial aging periods as the Geer test by exposure of the test piece for several days in air at 70 deg. cent. (158 deg. fahr.) and the oxygen-bomb test by exposure in oxygen at 300-lb. pressure at 70 deg. cent.

Tear Resistance.—This test is very important for grommets, channel strips, and indeed many other parts where one least expects high tear-resistance to be required.

Cutting Resistance.—This test is important for parts that are in contact with sharp metal edges.

Shear Test.—This test is variously performed, de-

[1] Manager, experimental compound and testing laboratory, Firestone Tire & Rubber Co., Akron, Ohio.

[2] See *Industrial and Engineering Chemistry*, February, 1928, p. 216.

pending upon the part in question. Shearing stresses are set up, not only in the new vertical type of engine supports, but also in spring shackles and many other parts.

Adhesion Properties.—In parts in which rubber is bonded to the metal during vulcanization, it is necessary to ascertain the strength of this bond, either by a tensile test or by some vibration test similar to the one herein described.

Resistance to Fatigue under Repeated Extension, Compression or Flexure.—One or more of these tests are highly important for such parts as rubber spring-shackles and torque insulators.

Deflectibility under Compressive Loads.—This is a true measure of the stiffness of stocks.

Hysteresis Properties under Static and Dynamic Stresses.—It is felt that these are perhaps by far the most important properties of rubber vibration-insulators, and consequently are made the major portion of this article.

Impact Tests.—These are important for such parts as spring, axle and door bumpers.

Sound Transmission.—Tests are made to determine whether energy is entirely dissipated or whether impacts, vibrations and sounds are transmitted 100 per cent or even made more objectionable because of resonance phenomena. Some very interesting and practical studies have been conducted by means of a solenoid accelerometer. This device has been described in considerable detail by R. W. Brown in numerous articles[a] in the last few years.

In short, tests are devised to show certain arbitrarily picked qualities of rubber stocks and, in addition, to know how well and how long a stock will function in an assembly the action and stresses in which are similar to those encountered in service, yet which are of necessity much more severe as to magnitude of stress, so that in a few minutes or days we can know the probable life of a part whose service life is several years or several hundred thousand miles.

Static Shock-Absorption Tests—Hysteresis

Probably the greatest shock-absorber known to mankind, at least to the aviator, is the parachute. The aviator jumps from his airplane and finally pulls the parachute release-cord. Instead of continuing to fall at a high speed, continually accelerated by gravity, his fall is broken upon the opening of the parachute, and he drifts to earth at a safe speed. The parachute has absorbed the kinetic energy acquired during his descent. Let us assume that this energy has been dissipated according to Curve *A* at the left in Fig. 1. If the jump were made without a parachute, the aviator would desire, unless suicidally inclined, to land on some material that would gradually retard the speed of his descent. Curve *O C M* at the center in Fig. 1 may be considered to show the general trend of this retardation. It represents, in fact, the load-deflection curve of the material used in this test. The area *O C M S O* represents the total energy absorbed. The perfect material for the purpose would be non-resilient, or at least inelastic to the extent of very slow recovery. In other words, it would not return the energy it had absorbed; the hysteresis loss would be 100 per cent, and likewise the permanent set.

Such a material would not, however, be suitable for automotive shock-insulators, for such parts must intercept and "iron out" repeated shocks of variable frequency and magnitude. Obviously, such a part must return to its original shape in time to function for the next shock or vibration. If this time interval is too short for the energy to be dissipated in other forms, some of it will be returned to the body imparting the original force or impulse. Although the ideal situation presents the anomaly of zero-per cent set and 100-per cent hysteresis loss, obviously a compromise between these two is necessary, and so presents an interesting compounding problem. The recovery curve may be represented by the line *M R O*. The area *O C M R O* represents the energy dissipated and hence is an indication of the energy absorbed by the material. Obviously, this area cannot be great if the material is to efficiently absorb vibration of a frequency higher than the reciprocal of the time required for the hysteresis cycle. Of course, resonance phenomena must be considered in any such statement.

The hysteresis loss of vulcanized rubber has been found to decrease after repeated stressing. This is true for both tensile and compression tests. A typical example is shown at the right in Fig. 1, in which the full lines *O C M* and *M R O* represent respectively the loading and recovery curves for the original stressing. The broken lines represent similar data obtained in a later cycle.

[a] See S.A.E. JOURNAL, June, 1928, p. 636.

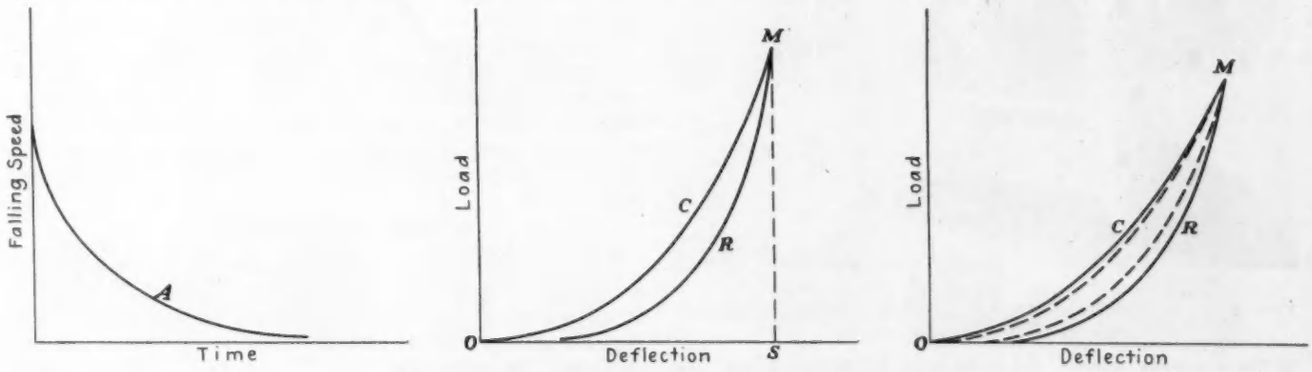


FIG. 1—CURVES ILLUSTRATING SHOCK ABSORPTION

(Left) Curve of Dissipation of Energy of a Falling Airplane-Pilot Checked by a Parachute. (Center) Curves of Energy Absorption by a Cushion Material on Which the Pilot Might Fall and of Energy Return by the Material. (Right) Loading and Recovery Curves of Vulcanized Rubber, Showing Hysteresis Loss, Which Decreases after Repeated Stressing

A Laboratory Compression and Hysteresis Machine

Compression and hysteresis data may be obtained from tests made in any suitable device. Fig. 2 shows the compressetometer, which has been found very useful in developing new stocks and comparing test pieces cut from various rubber specimens. By means of a hand-wheel, *A*, the plunger *B* is made to descend upon a test piece held rigid in or against the base *C*. At *D* is an adjustable spindle for use in setting the zero point at the moment of contact of the plunger and the test piece. Compressive loads are read on the scale *E*. Tests can be conducted at normal temperatures and also at both higher and freezing temperatures. In the cold test, the lower end of the compressetometer is immersed in a vessel containing a freezing mixture. Considerable care is necessary in these tests in order to get truly comparative data. This equipment, together with a rather detailed discussion of such precautions, is described in an article by me in the Analytical Edition of *Industrial and Engineering Chemistry*.[4]

As will be noted from Fig. 2, the device is suitable for stiffness tests on actual engine-supports. In this way the rigidity factor of the rubber in the support can be determined, and the tests are sufficiently accurate to check the ordinary compression-tests on test pieces obtained from laboratory slabs. Some typical deflection data on the vertical type of engine supports shown in Fig. 2 are given in Table 1.

[4] See *Industrial and Engineering Chemistry*, Analytical Edition, April 15, 1930, part II, p. 153.

[5] See *Industrial and Engineering Chemistry*, February, 1928, p. 216.

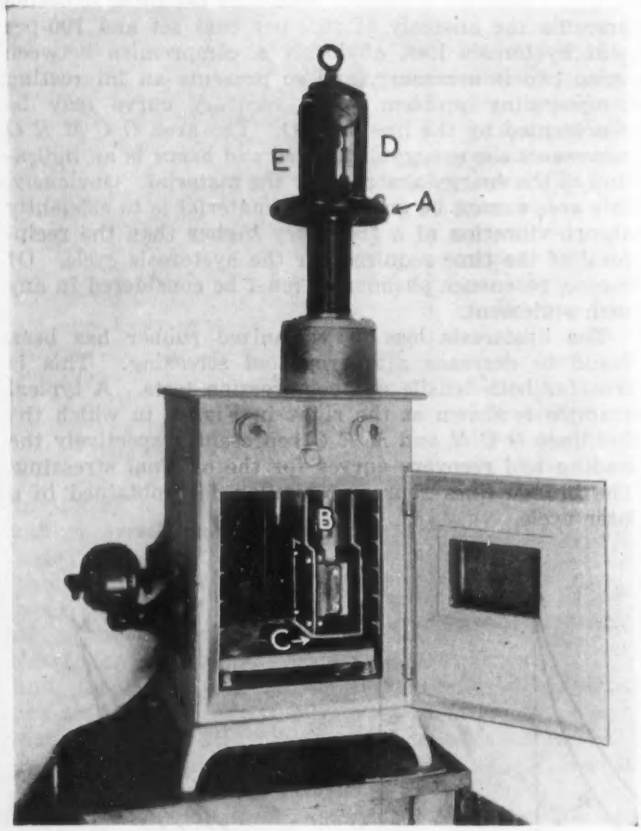


FIG. 2—COMPRESSETOMETER FOR MAKING RUBBER COMPRESSION AND HYSTERESIS TESTS

A Vertical-Type Rubber Engine-Support Is Shown under Test within the base. By Means of Hand-Wheel, *A*, the Plunger *B* Is Forced Down upon the Test Piece Held Rigid in or against Base *C*. An Adjustable Spindle at *D* Is Used for Setting the Zero Point at the Moment of Contact of the Plunger and the Test Piece

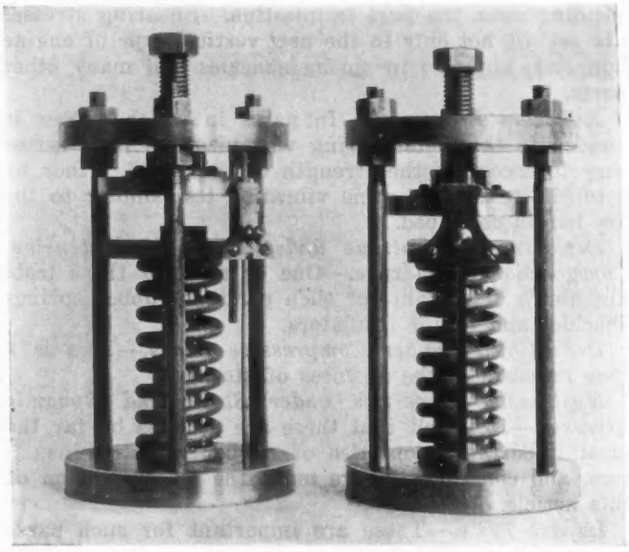


FIG. 3—COMPRESSION-SET CLAMP FOR STATIC FATIGUE-TESTS ON RUBBER COMPOUND

Used for Measuring Resistance of Parts Assembled under Compression or High Flexure-Set of Torque Insulators, Spring Shackles and Silent Blocs to Steady Compressive Loads or Distortion

TABLE 1—DEFLECTION TESTS ON METAL-TO-RUBBER VERTICAL ENGINE SUPPORT

Stock	A.S.T.M. Penetration, 0.001 In.	Deflection at 500 Lb.
1	100	0.102
2	95	0.050
3	65	0.042
4	50	0.031

[6] See *Proceedings of the American Society for Testing Materials*, vol. 29, 1929—Part I, Tentative Standard D314-29T.

Hysteresis loss, as determined by the foregoing test, is not necessarily a measure of the resistance to fatigue which shows up in high compression-set, particularly in parts assembled under compression, or high flexure-set in such parts as torque insulators, spring shackles and silent blocs. This is true because the practical optimum qualities of a rubber part are obtained by compromise between the actual optimum individual properties. To determine to what extent a compound will withstand static fatigue-tests, that is, steady compressive loads or distortion, tests are conducted in the compression-set clamp shown in Fig. 3. Standard methods of tests have been described in the article[6] last referred to.

Dynamic Hysteresis-Tests

The foregoing two tests have often been referred to as static compression or fatigue-tests to differentiate from dynamic hysteresis-tests such as are made in a repeated-flexure device under compression. This device, designed to simulate the flexure of rubber parts assembled under compression, is shown in Fig. 4. As originally described[5] it was designed for repeatedly flexing blocks of rubber at constant distortion, but it

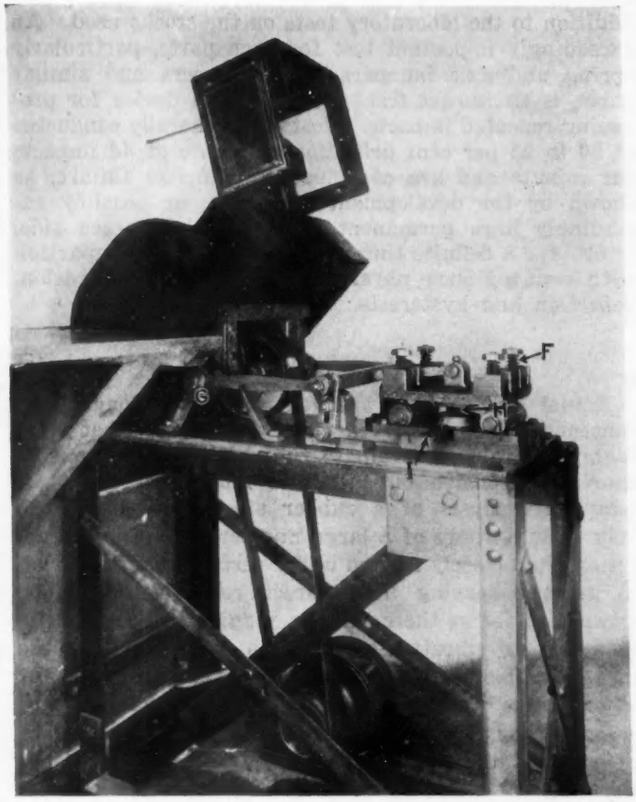


FIG. 4—FLEXOMETER FOR REPEATED-FLEXURE TESTS AT CONSTANT LOAD

Constant Load Is Maintained by Calibrated Springs, *F*. An Eccentric, *G*, Oscillates the Top Plate at a Rate of 800 Cycles per Minute. Test Piece *H* Is Subjected Both to Flexure under Compression Due to To-and-Fro Motion of the Top Plate and to a Rotary Oscillation Imparted by the Torque Unit *I*

has been revamped, as shown, to conduct tests at constant loads obtained by means of accurately calibrated springs, *F*.

Oscillation at the rate of 800 cycles per minute is obtained by means of the eccentric *G*. The test piece *H* is subjected, not only to flexure under compression due to the to-and-fro motion of the top plate, but to a rotary oscillation imparted by the torque unit *I*. This latter action is designed to simulate the torque action sustained by engine supports during certain stages of the operation of a car. The machine likewise simulates, to a considerable degree, the sidesway factor in rubber spring-shackles (See Fig. 5). Under suitable pressure and throw of the top plate, test blocks of high-quality stocks can be made not only to acquire a permanent set approaching in magnitude the percentage deflection used during the test, but the test piece may actually be caused to melt (See lower right in Fig. 5). This last suggests the use of this equipment in the study of energy dissipation or blow-out. Active testing on such a program is in progress.

The flexometer is suitable for oscillation tests on the vertical type of engine support which is fast becoming popular in many cars of today. The tie-bolts and top plate of the flexometer are removed. The frame side of the engine support is bolted to the base of the flexometer, and a fixture fitted to the engine-bracket side of the support is attached to the flexometer drive-arm. No compression is used, as such action does not occur in service. In this way studies are conducted to determine the efficiency of the bond between the rubber and the metal.

It is interesting to note that rubber vibration-insulators find practical use in the laboratory as supports for the flexometer itself. Trial tests have shown that, with correctly designed supports of the right size, the vibration of this machine can be entirely insulated from the floor on which it is mounted.

Importance of Dynamic Hysteresis-Tests

The greater importance of the flexometer tests, in comparison with static hysteresis-tests, can well be understood when it is considered that in the latter the cycle is exceedingly slow, whereas, in the most important applications of automotive rubber-parts, the cycle is mostly a very rapid one. The frequency of the cycle has a marked effect on the area and shape of the hysteresis loop. In other words, data obtained in

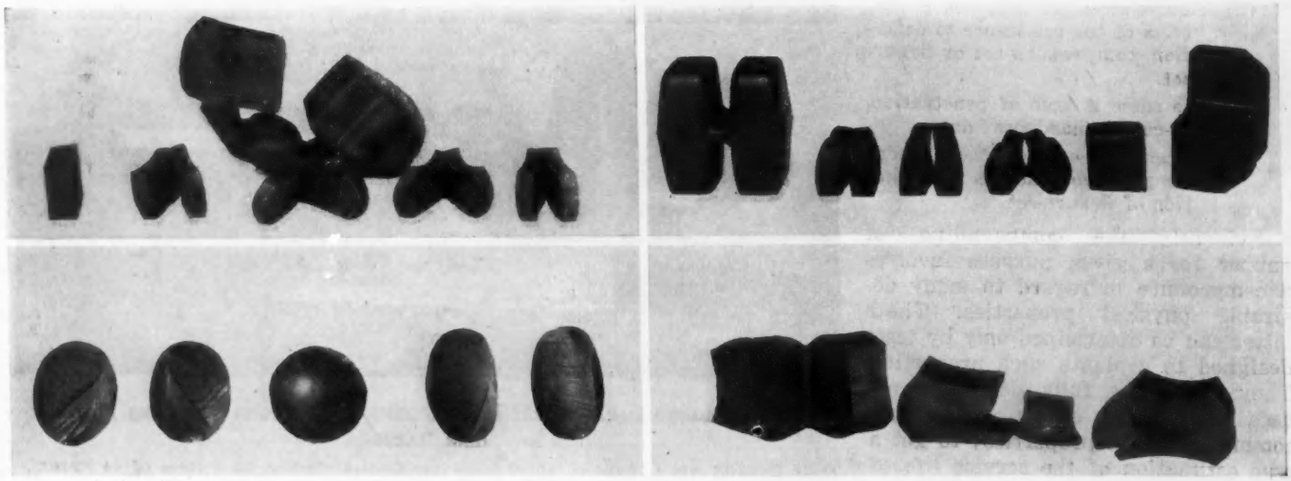


FIG. 5—RESULTS OF FLEXOMETER TESTS ON RUBBER SPRING-SHACKLES AND TORQUE DRIVE-BALLS

(Upper Left) Shock Insulators after Subjection to Tests. (Upper Right) Torque Insulators before and after Test. (Lower Left) Effect of Tests on Torque Drive-Balls. (Lower Right) Effect of Energy Dissipation or Blow-Out

TABLE 2—PHYSICAL TESTS ON SOME VIBRATION-INSULATION STOCKS

Tensile Tests

	Stock A	Stock B[6]	Stock C	Stock D
Stress at 400 Per Cent Elongation, lb. per sq. in.	1,715	1,900	700	1,050
Stress at Break, lb. per sq. in.	3,500	4,000	2,500	3,200
Ultimate Elongation, per cent	550	550	650	650

Static Compression-Tests at 600 Lb. per Sq. In. on ¾-In. Discs of ¼-In. Slabs

	A	B[6]	B-1[7]	C	D
Penetration, 0.001 in. (A.S.T.M.)	53	59	63	79	62
Compression Set, per cent	27	11	7.9	31	31
Maximum Deflection, per cent	43	44	49	48	48
Loading Energy, lb.	11.5	10.2	12.3	10.1	10.2
Hysteresis Loss	4.7	2.9	4.8	2.6	2.8

Flexometer Tests at 178 Lb. per Sq. In.[8]

	A	B[6]	B-1[7]	C	D
Maximum Deflection, per cent	22	28	27½	33½	31
Flexure Set, per cent	5	3½	1½	5	25
Flexure Set at 50 Per Cent Deflection, per cent	19	7	5½	9½	34

[6] This stock can be so cured as to possess less than 2 per cent compression-set by the same test but to the detriment of certain other properties.

[7] Cured to possess the same hysteresis loss as that of stock A for purposes of comparing the respective set data.

[8] Tests were conducted for ½ hr. at 800 cycles per minute on test blocks 1½ x ¾ in. x 1 in. (height).

evaluating one or more physical properties of rubber should not, in general, be used in judging many of the other physical properties.

Table 2 gives some important comparative data of some possible shock-insulator stocks. The outstanding facts in this table are:

(1) The energy absorbed during compression is not a measure of compression-set or of flexure-set (dynamic fatigue).

(2) An increase in hysteresis loss in the first compression cycle can be attended by lower compression-set and also lower flexure-set (second series of tests on Stock B).

(3) Tensile-strength data are no criteria of the resistance to deflection, compression set or flexure set.

(4) The same is true of penetration, so-called "hardness" data.

(5) Percentage of deflection under compressive loads is no criterion of flexure-set.

Evidently the compounding of rubber for a given purpose involves a compromise in regard to many desirable physical properties. These latter can be determined only by tests designed to evaluate such properties. They cannot be fully deduced from data obtained for a few of the more common physical properties; to get a true estimation of the service life of a given part, tests simulating the service conditions must be made.

Automotive engineers often desire special tests on the assembled part in addition to the laboratory tests on the stocks used. An exceedingly important test for such parts, particularly spring and axle bumpers, door bumpers and similar parts, is an impact test. Fig. 6 shows device for producing repeated impacts. Tests are generally conducted at 50 to 55 per cent deflection at a rate of 44 impacts per minute and are continued to complete failure, as shown by the development of cracks, or possibly exceedingly high permanent set shown by bulged side, or else for a definite time with a subsequent comparison with tests of such physical properties as penetration, deflection and hysteresis.

Conclusions

Actual service tests are generally so prolonged and consequently so costly in time and money that it is highly desirable to evaluate rubber parts by means of short, inexpensive but accurate laboratory tests. A complete analysis of a rubber stock is accomplished only from a study of a large number of physical properties often closely related under certain conditions, yet in general bearing little direct relationship to one another as far as their value in judging the service life of a rubber vibration-insulator is concerned. In the case of rubber vibration-insulators, even more than for other rubber parts, it is highly desirable that these be evaluated only by tests simulating actual service conditions, particularly as regards types and frequencies of stressing.

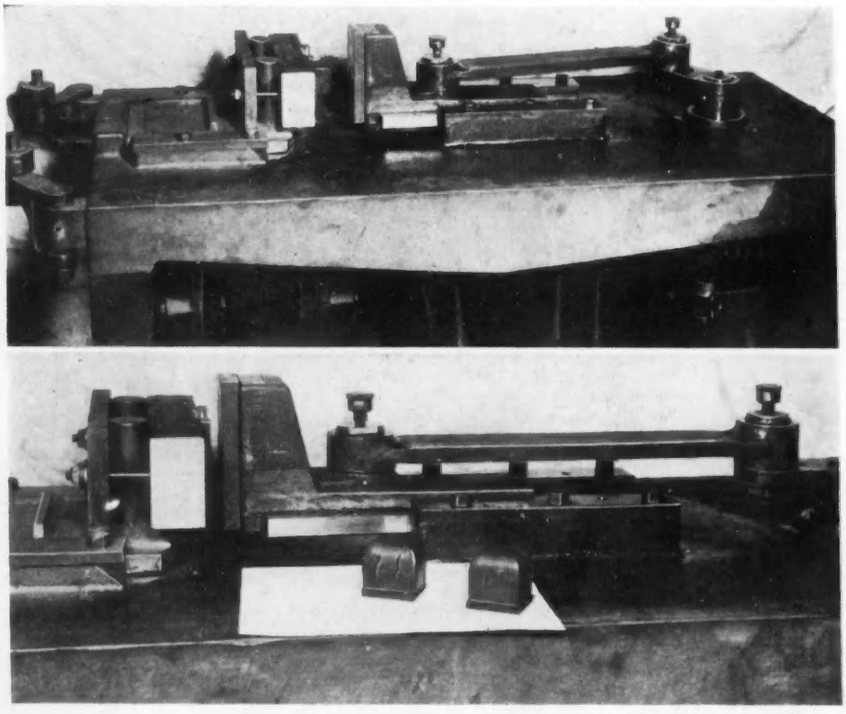


FIG. 6—REPEATED-IMPACT TESTING MACHINE FOR RUBBER BUMPERS AND SIMILAR PARTS

Tests Usually Are Conducted at 50 to 55 per Cent Deflection at a Rate of 44 Impacts per Minute. A Rubber Bumper To Be Tested Is Shown in the Upper View in Location on the Anvil to the Left of the Reciprocating Ram. Below Is Seen the Ram at Full Stroke for 54-per Cent Deflection Tests on Bumpers Shown Below the Ram. The Bumper at the Left, of One Stock, Was Subjected to Impact for 1½ Hr. and That at the Right, of Another Stock, to Impact for 16 Hr.

Standardization Progress

Proposed Machine-Pin Standard

Submitted for Taper and Cylindrical Pins by American Standards Association Committee

ABOUT eight years ago, the Office of the Chief of Ordnance, United States War Department, suggested that the American Engineering Standards Committee, now the American Standards Association, authorize the standardization of machine-shop tools under its procedure. Among the subjects proposed for standardization were split and taper pins and other pins used in ordinary construction work. The American Standards Association decided to undertake the project and a committee was organized under the sponsorship of the American Society of Mechanical Engineers and subsequently the co-sponsorship of the S.A.E. This committee did not make much progress and in 1926 was reorganized. After gathering many data on machine-pin practice, a preliminary proposal was circulated about a year ago for critical comment by industry. Further study of the subject resulted and the committee now submits the accompanying proposal.

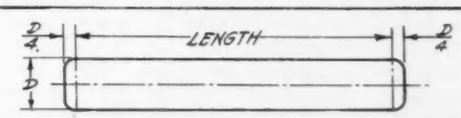
In presenting the report, the Committee on Machine Pins points out some of the objectionable features of the present series of pins, such as the indefinite, irregular and inconsistent progression of sizes, unnecessary intermediate sizes, and the use of the large diameter as the basis for size designation. The related dimensions of the pins and their reamers, particularly the overlap of a reamer beyond both ends of a taper pin of maximum length, were also cited as a real reason for a new standard.

In considering the relation of the proposed pin standards to the reamers, it is pointed out that, with the minimum and maximum lengths of pin set at 4 x *D* and 12 x *D* respectively, the length of taper pin reamers could be set to provide an overlap of *D* at each end of a pin of maximum length, making the cutting blades equal to 14 x *D* and a relationship established that would provide for a consistent progression of reamer dimensions corresponding to the elements of the pins themselves. The taper of the proposed series is ¼ in. per foot, or a ratio of 1:48. The small diameter of the pins, which is the nominal, is in usual fractional dimensions, the smallest value of which is given in 1/32 in. The number of diameters in the proposal is a reduction from 20 to 14, and lengths are limited to between 4 and 12 times the small diameter of pins, varying in logical progression to give the maximum utility with the minimum variety.

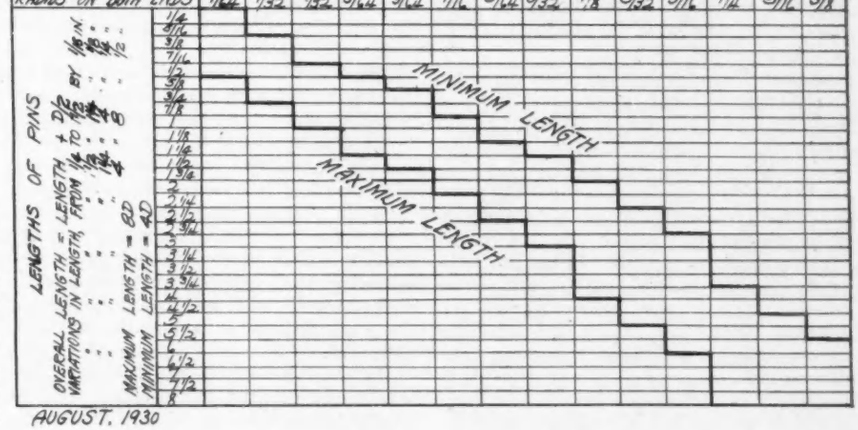
In the table of cylindrical pins, the maximum lengths are given as 8 x *D* instead of 12 x *D* as for the taper pins. To provide for various fit requirements, three classes of tolerance, in the approximate ratio of 1:2:4 to provide for fine, medium and coarse fits, are recommended, it being anticipated that pins within the medium or Grade B

(*Concluded on p.* 617)

PROPOSED AMERICAN STANDARD CYLINDRICAL PIN PROPORTIONS AND SIZES

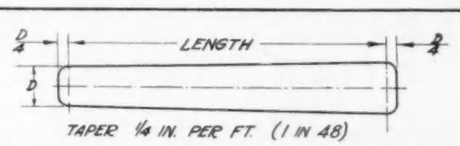


DIAMETER, MAXIMUM	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2
GRADE A, TOL. = .0005 + .003 D	.0003	.0003	.0003	.0003	.0003	.0004	.0004	.0004	.0005	.0005	.0005	.0006	.0006	.0007
GRADE B, " = .003 D	.0007	.0007	.0007	.0007	.0007	.0008	.0008	.0009	.0010	.0011	.0012	.0013	.0014	.0015
GRADE C, " = .005 D	.001	.001	.001	.001	.001	.002	.002	.002	.002	.002	.002	.003	.003	.003
RADIUS ON BOTH ENDS	1/64	1/32	1/32	3/64	3/64	1/16	5/64	3/32	1/8	5/32	3/16	1/4	5/16	3/8

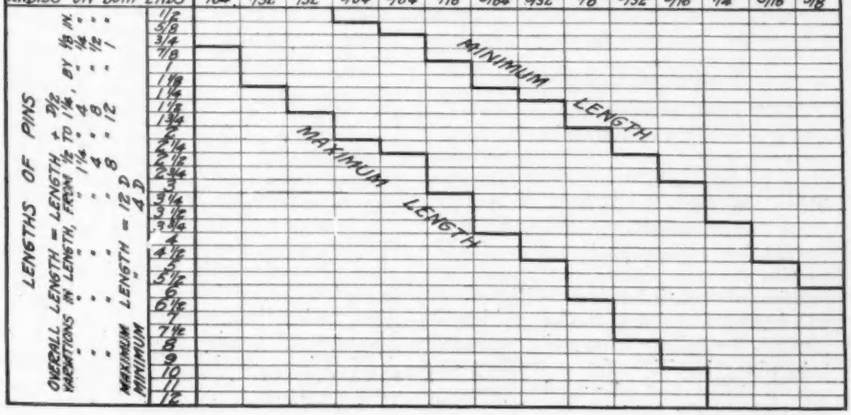

LENGTHS OF PINS
OVERALL LENGTH = LENGTH + D/2
VARIATIONS IN LENGTH, FROM 1/16 TO 1/4, BY 1/16
" " " 1/4 " 1/2 " 1/8
" " " 1/2 " 1 " 1/4
MAXIMUM LENGTH = 8D
MINIMUM LENGTH = 4D
MINIMUM LENGTH
MAXIMUM LENGTH

AUGUST, 1930

PROPOSED AMERICAN STANDARD TAPER PIN PROPORTIONS AND SIZES



DIAMETER AT SMALL END	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1	1 1/4	1 1/2
" , MINIMUM	.0620	.0932	.1245	.1557	.1870	.2495	.3120	.3745	.4990	.6240	.7490	.9990	1.124	1.499
" , MAXIMUM	.0630	.0942	.1255	.1567	.1880	.2505	.3130	.3755	.5010	.6260	.7510	1.001	1.126	1.501
RADIUS ON BOTH ENDS	1/64	1/32	1/32	3/64	3/64	1/16	5/64	3/32	1/8	5/32	3/16	1/4	5/16	3/8


LENGTHS OF PINS
OVERALL LENGTH = LENGTH + D/2
VARIATIONS IN LENGTH, FROM 1/2 TO 1 1/4, BY 1/4
" " " 1 1/4 " 4, " 1/2
MAXIMUM LENGTH = 12 D
MINIMUM LENGTH = 4 D
MINIMUM LENGTH
MAXIMUM LENGTH

Transportation Engineering

Drivers and Traffic Control

C. P. Taylor's[1] Traffic-Officer's Manual Valuable for Fleet-Drivers' Training-Background

THE personnel of most agencies dealing with street traffic is increasing rapidly, and it is difficult to develop traffic officers properly qualified in aptitude and in training although, in established traffic-departments, an unprecedented demand exists for conscientious men capable of meeting the requirements of traffic control. Similarly, fleet operators' greatly extended operations have made it difficult for them to develop capable and conscientious drivers. Clarence P. Taylor's newly written Traffic Officer's Training Manual, published by the National Safety Council, Chicago, is therefore helpful to fleet superintendents, and should be available in every drivers'-training-school library.

Primarily intended for training traffic-officers so that they may have a sufficient background of knowledge and experience to control traffic satisfactorily, the manual has another bearing in that much of the information presented gives drivers of automobiles, motorcoaches and motor-trucks a better understanding of how broad a field traffic requirements cover and how necessary it is that these drivers cooperate with the police in bringing about more satisfactory operating conditions for motor-vehicles on the highways. Traffic-control work is complicated and is changing rapidly. Motor-vehicle drivers as well as traffic officers must know the latest innovations in traffic control, thereby educating themselves so that they are competent to give maximum cooperation.

When the traffic control was assigned to police departments, difficulties in administration arose. The bureaucratic form of organization, now so prevalent in the larger cities, indicates the growth in size and complexity of the problem, and also the necessity for professionally skilled traffic executives and officers, as well as thorough cooperation from every motor-vehicle driver.

Enforcement's Part in Relief Plan

Lessening accidents constitutes the most pressing aspect of the traffic problem. Traffic is a great business problem as well as a public-safety problem. For good traffic-regulation, the method of control should fit the traffic, rather than have the traffic fit the method. Vehicular traffic follows the easiest path, over routes which are least obstructed, shortest in distance or time, smoothest, widest, least congested or more accessible. Traffic at any particular place fluctuates hourly; not uncommonly it has three or four "peaks" per day, and varies each week-day, compared with the other week-days. Seasonal changes are indicated clearly when the traffic volume from month to month is compared; volume of traffic increases yearly, varying considerably over different routes, and may increase or decrease within short distances on the same route.

The traffic stream is not uniform in character. Vehicular traffic constitutes one important class but it is composed of heavy slow-moving motor-trucks, motorcoaches and some very slow-moving horse-drawn vehicles, as well as a large number of light, fast, passenger-cars. Street-car traffic forms an important part of traffic movement. Although the street-cars move on the same streets with motor-vehicle traffic, their operating characteristics are very different.

Pedestrians compose a third class which differs radically from wheeled traffic in its movement and in its demands for control and protection. A good system of regulation will take into account the special requirements of all classes and will balance the control provisions so that each will be benefited and protected.

Just as the problem of traffic-control is comprehensive and very serious in its effect, so a good plan of relief must be comprehensive and intelligent in its design. Traffic relief needs three supports: competent *engineering*, thorough *education*, and intelligent *enforcement*.

Control at Intersections

Traffic rules which are in effect but are not really needed probably exist in every city and town. Officers and their departments have a share of responsibility for such conditions, where they have recommended an ordinance or a device, but this often is a result of deferring to the almost continuous persuasion of well-intentioned citizens who are trying to solve a traffic problem by control. To relieve congestion at a certain place intelligently, a traffic count and a delay test should be made; if less than 1000 vehicles per hour pass through the intersection, this is almost conclusive evidence that special control is not needed.

The basic principle should be to devise a remedy first and then to invent a means of regulation. Where more than two streets intersect, rotary control works out especially well; that is, when all traffic entering an intersection is required to keep to the right around an obstruction, usually a circle located in the middle of an intersection. This has the advantage of eliminating the need for "stop" and "go" regulation; but, where the volume of vehicular traffic is large and the pedestrian problem is acute, stop and go methods are sometimes employed in addition.

Safety islands have been found useful in making crossings safer and easier for pedestrians. In other cases of rotary traffic, the only change needed is a circle marked on the pavement and a few "keep to the right" signs strategically located. A circle of 65-ft. minimum-diameter has been suggested, although the minimum size of such a circle has never been conclusively determined.

Driver and Police Cooperation

Both human and automatic control are discussed in Mr. Taylor's book. He says of human control that, even with the increased use of mechanical devices, the traffic officer at intersections is still a familiar sight and probably will continue to be so, because no traffic-control device can be as mobile and adaptable as a good traffic officer. From this it can well be argued from the viewpoint of driver cooperation that no device on a motor-vehicle can be as mobile and adaptable as a good motor-vehicle driver who has a background of knowledge regarding traffic rules and a sincere intention to cooperate with the police traffic-officers. Superintendents of fleets of motor-trucks and motorcoaches might emphasize this point to good advantage in line with the drivers' training-courses which many of them are now inaugurating.

Pedestrian protection and control are also features which must be given increasing consideration in that, as Mr. Taylor says, failure to give adequate care for pedestrian traffic is a common occasion for criticism. While it is true that pedestrians often fail to take advantage of special efforts in their behalf, it is recognized that care for them gradually will increase the willingness of individuals constituting the general

[1] Fellow of the Albert Russel Erskine Bureau for Street-Traffic Research, Harvard University, Cambridge, Mass.

walking public to await their proper turn in traffic. Moreover, elderly people, children, those who are infirm, and others, actually require special protection.

Even where no special pedestrian period is provided, pedestrians can be assisted greatly if the traffic officer allows a reasonable time, say several seconds, to clear the street before releasing traffic in a cross direction. This also is a point in which drivers can promote safety by cooperating with the traffic officers. Too many drivers try to *beat* the closure of a go-signal period, and to *rush* the next "Go" signal.

Turns and Turn Prohibitions

The prohibition of turns of any sort is not consistent with good traffic-regulation as a rule; but an analysis of conditions may prove such prohibition necessary. Tests should determine the prohibition's efficacy at an intersection before final adoption of the rule. The National Conference on Street and Highway Safety has wisely recommended against the permitting of turns while a red signal is displayed, except under unusual conditions, and then only when the exception is clearly indicated by a green arrow. Turns into a one-way street are considered valid exceptions. In general, turns are to be made only on the green light. In some special cases the signal provides a special interval for making turns. Diagrams in Mr. Taylor's book illustrate points relating to the left turn, which is the main cause of difficulty at intersections, and other turns.

Parking Problem Discussed

Nothing can properly orient the public in regard to parking so well as a comprehensive parking survey, says Mr. Taylor. Such a study can do more to bring about cooperative action than any other one thing. The survey should determine how more parking space can be obtained, how that which already exists can be more effectively utilized, and what other means can be employed. Since parking space at the curbs in most business districts is already overcrowded, additional space can be provided in several ways.

Business men should be educated to conduct their deliveries and parking of company cars in such manner as to eliminate unnecessary obstruction. Public or private lands suitable for parking lots can be utilized. Where accurate studies make the need clear, it is usually found that business men are willing to build garages. Occasionally, a minor and inexpensive widening of a street may serve to give added space. Time limits are necessary in crowded parking districts to keep a comparatively few all-day parkers from monopolizing the entire space. People who park motor-vehicles are of both the short-stay and the long-stay classes, the latter being those whose business calls for an extended shopping tour, a business conference or a lengthy visit.

Five Practical Parking Schemes

Only five practical arrangements for parking motor-vehicles can be made; (*a*) parallel, (*b*) diagonal headed-in, (*c*) diagonal backed-in, sometimes termed semi-parallel, (*d*) right-angle headed-in, and (*e*) right-angle backed-in. As to which, if any, is the best for a particular street or block, the factors to be considered are, safety, the demand for parking space, the demand for street width, ease in use, and interference with passing traffic. The author fully discusses details of these parking plans.

Planning and Tests Prevent Accidents

In the chapter in which the handling of crowds caused by processions, fires and disasters, as well as by sport events, entertainments and social affairs is discussed, emphasis is given to the necessity for special planning.

Statistics compiled from accident reports seldom show headlights as causing accidents in more than 1 per cent of the cases, because no general effort is made to determine what part the condition of headlights played in the accidents. In one series of accident investigations by A. W. Devine in Massachusetts, defective headlights were a contributing cause in 13 per cent of the cases and a principal cause in none. The book states that several manufacturers provide a small colored window in the back of every headlamp, through which the light of the burning globe can shine, thereby enabling the driver to know whether his lights are burning. A more recent device is a tiny mirror attached to the top of the headlight rim so that a small beam of light is reflected back to the driver. Many officers, drivers and citizens have long recognized the valuable service that can be rendered by calling the attention of passing motor-vehicle drivers to the fact that their headlights are unlit.

Mr. Taylor says that accidents due to faulty materials or construction are extremely rare. Accidents are chiefly caused by careless maintenance. He describes means for testing brakes, steering gears, speedometers and the like, including illustrative charts and tabular data, mentioning also the personal equation or reaction time of the driver from the time a condition arises requiring instantaneous application of the brakes until the brakes actually are applied and take effect. This is a matter upon which the United States Bureau of Standards has made experiments. According to these tests, the average person takes approximately ½ sec. to perceive an emergency, put his foot on the brake pedal and apply the brakes, although this factor is variable in that some drivers react quickly and some drivers are slow to act.

Other Traffic-Enforcement Problems

Saying that every part of the traffic law has its own peculiarities and that each requires special consideration as to the best technique for enforcement, Mr. Taylor discusses the offenses for which the number of arrests is generally large, including vehicle speed, overloaded vehicles, licenses and registrations, cutting in and cutting out of line, passing street-cars, and the proper use of safety zones. The remedy for these lies largely with drivers. Another chapter is devoted to the handling of violators with regard to theory and to practice. The subjects of arrest and prosecution, the use of firearms and the management of a violations bureau are treated also. In the chapter on prevention of accidents and the expedition of traffic movements, it is stated that the tools with which these ends can be accomplished are the law, scientific knowledge, engineering developments and applications, and education.

The author says also that every community has its own safety problem and that the work of no two local safety-councils is exactly similar. Further, that to form and operate a local safety-council without the advice and assistance of the National Safety Council would be like trying to form and operate a corporation without the aid and assistance of a capable corporation attorney. All of the foregoing points indicate how necessary it is that all drivers understand the traffic-congestion situation, thereby enabling themselves to cooperate intelligently with the various traffic authorities.

Traffic-Control Investigations

Accident report-forms, statistics, and traffic-hazard investigations are treated by Mr. Taylor in subsequent chapters which are illustrated by diagrams and charts. The routine to be followed at the scene of an accident is stated in detail, and the equipment needed for making traffic investigations is listed. The subject of investigation and preparation of criminal cases is analyzed, as are also court procedure, the taking of testimony, and cross-examination. In the final chapter human relations are discussed, since the human element is the predominating factor in the work of traffic control.

In regard to public relations, unless a police department has the confidence of the public, it will not secure adequate cooperation from the public and consequently it cannot operate efficiently. It is here that all drivers of automobiles, motorcoaches and motor-trucks can effectively assist the traffic police toward the accomplishment of adequate traffic-control. Since this is true, it would be of undoubted benefit if, in the training of drivers, each driver were encouraged or required to acquaint himself with the problem from

the traffic officer's viewpoint, so that he will do what he individually can to cooperate with the police in improving traffic conditions greatly, and thus personally help to relieve the very serious traffic-congestion that now exists. Motor-vehicle drivers and traffic-police officers should not be *enemies;* they should be *friends.*

Regulation of Motor-Vehicle Common-Carrier Business

REGULATION of motor-vehicle common-carriers involves two important considerations, according to the Motor-Vehicle Conference Committee; first, regulation of the actual physical characteristics and physical operation of motor-vehicles used as common carriers and, second, regulation of the business engaged in by motor-vehicle common-carriers.

The first consideration is adequately cared for by existing State laws. Motor-vehicles operated as common carriers are, in this respect, subject to the same regulation as are other motor-vehicles. This consideration is treated in a pamphlet entitled, State Restrictions on Motor-Vehicle Sizes, Weights and Speeds, published on Jan. 1, 1930, by the Committee.

Classes of Operation

Regarding the classifications, Class *A* includes motor-vehicles privately employed by their owners for the transportation of persons or property. Class *B* represents the private contract carrier. Motor-vehicles in this class are employed by their owners for the transportation for hire of certain persons, or property of certain persons, to places prescribed in individual agreements entered into for the purpose. Class *C* is representative of the common-carrier. It is comprised of motor-vehicles employed by their owners for the transportation for hire of all persons, or the property of all persons, indiscriminately, under general conditions of agreement applicable to the whole public.

The constitutional rights of the private operator, Class *A*, and the private contract carrier, Class *B*, exempt this portion of their business from regulation. The Supreme Court of the United States has ruled that the private contract carrier, Class *B*, cannot be forced to operate as a common-carrier, Class *C*. It necessarily follows that, up to the present, the regulation of the business of operating motor-vehicles has been confined to that of the common-carrier, Class *C*.

Scope and Type of Operation

Regulation of the business of operating motor-vehicles has been further confined to operations wholly within a State, as the Supreme Court of the United States has ruled that a State has no jurisdiction over operations which cross a State line.

It has recently been suggested that the regulation of the business of operating motor-vehicles should be still further confined to the transportation of persons. The motorcoach-riding public is yet to be heard from in this connection. If a common-carrier, Class *C*, motorcoach-operation which must, of necessity, be conducted as a monopoly, is to be subject to State regulation, it must be the same type of regulation that is used in controlling other forms of public utilities. In this type of operation, the chief value to the public lies in regularity or inflexibility of service.

Experience in the transportation of property by motor-vehicles, however, has demonstrated that its chief value to the public lies in its flexibility of service, particularly in emergencies, which will be limited, if not destroyed, by regulation. Common-carrier motor-truck operation, Class *C*, cannot be conducted as a monopoly. Regulation of its business cannot protect it against private-carrier motor-truck competition Class *B*, nor can it benefit the shipping public.

The power to regulate intra-State transportation by motor-vehicle common-carriers, in the last analysis and with few exceptions, rests with the State. These few exceptions occur in States whose constitutions provide for a very broad rule for municipalities. Until a few years ago our States in no way differentiated between common-carrier and other uses of the motor-vehicle. In 1914, however, Pennsylvania definitely segregated motor-vehicles when used as common-carriers and placed them under the regulation of the State's public-service commission. Today, the laws of 47 States and the District of Columbia regulate passenger carriers to a comparatively complete degree, and 37 States and the District of Columbia regulate property carriers to a greater or less degree.

Signs and Signals

ONE of the most important topics discussed at the Third National Conference on Street and Highway Safety was the report of the American Engineering Council Committee recommending certain changes, mostly of minor yet of important character, in the report on Street Traffic Signs, Signals, and Marking already published and distributed by the Council last year. The important changes as finally adopted by the Conference are:

(1) A recommendation to use non-corrosive screws and washers for attaching signs to their supports to avoid discoloration.

(2) A reference to recent action of the American Association of State Highway Officials in approving red letters on yellow background for the standard stop-sign as an alternative to their original standard of black on yellow.

(3) Signs are to be placed so that no part will be closer to the curb line than 12 in. Signs should not unnecessarily be placed on or within 10 ft. of poles which have to be climbed.

(4) Railroad-crossing signs, in the case of multiple tracks, should indicate the number of tracks.

(5) At railroad crossings where a stop is mandatory, use the standard stop-sign.

(6) At the entrance to an irregular series of curves, use the slow sign with the word "Curves" and an arrow indicating the direction of the entering curve.

(7) A square caution-sign with the words "Cross Street" is to be used at every crossing which is hazardous and requires caution but which does not warrant a stop or a slow-sign. The slow-sign for more hazardous intersections is to contain the wording "Dangerous Corner." The standard stop-sign is, of course, retained for those intersections requiring it.

(8) On direction signs an arrow is to be placed at the side of the message rather than below it.

(9) In the parking-restriction signs a reversal of the colors for background and lettering is permissible, provided the meaning of the colors is retained; that is, red for prohibited parking and green for permitted parking.

The classification of traffic signal-systems is changed to flexible progressive, alternate, simultaneous, and independent. These terms are defined in the usual way. The discussion of the different types of system is somewhat amplified, the flexible progressive being recommended. In harmony with the Model Municipal Traffic Ordinance, definite preference will be expressed for the three-color system. Yellow alone is not to be used as a special period for the turning of vehicles or the movement of pedestrians. Mention is made of recent installations in Detroit and Pittsburgh giving special indication to pedestrians when it is no longer safe for them to start across the intersection, as well as the use of a special color-combination for pedestrian movement only, in Massachusetts.

Change Curb-Marking Color-Schedule

A few minor changes are made, relating to railroad-crossing signals and markings, conforming to the standard railroad specifications. The color schedule for curb markings is changed to read: prohibited stopping, red; passenger-loading zone, white; loading zone for passengers and material, yellow; limited-time parking, green.

The recommendation for a clearance of 4 in. between raised safety-zones and the widest street-cars is omitted because of the variation in widths of cars. The section on location of signals has been changed to state no preference as between far and near-side location. —*Public Safety.*

Sixth International Road Congress

Varied Problems Discussed and Conclusions Drawn by Delegates from Many Countries—Exhibits, Demonstrations, Receptions and Tours

A CONVENTION of momentous importance to world economic progress, and in particular to the automotive industry, was held in the City of Washington, Oct. 6 to 11. Highway experts representative of almost every country in the world met to submit for discussion the results of research and experience bearing on all phases of highway development and use. The medium for this interchange of the opinions of internationally honored authorities on matters of highway and motor-transport development is the Permanent International Association of Road Congresses.

Conclusions Important to Automotive Engineers

Of special interest to automotive engineers were some of the results of the deliberations of the Congress. In discussing ways and means of financing highways, it was concluded that, to facilitate financing and administration and as a guide for determining the kind and extent of improvement, all highways should as far as practicable be classified according to the characteristics of their prevailing traffic as to origin, destination and importance. Classifications usually applicable are General-Use Highways, including primary or national highways and secondary, departmental, provincial or, in countries of small geographical area, county highways; Highways of Local Interest, taking in local roads and urban streets; and Special Highways, comprising military roads, autostrades and the like.

The treatment by the Congress of the subject of the correlation and coordination of highway transport with other methods of transport brought out the view that the development of highway transportation through the use of the motor-vehicle has not been of equal intensity in all countries. To the extent that this development has gone on in a country, the problem of the coordination and correlation of highway and rail transportation facilities has become more pressing in its demand for a solution based upon broad economic and scientific principles so that the public as a whole may enjoy the maximum benefits of all its transportation agencies.

The opinion was also expressed that in certain situations it is found that the small amount of traffic that highway common carriers might draw from the railways is largely compensated by the feeder service which they afford to main lines of railroads. This is especially true in mountainous countries where railway construction is very expensive and the automobile has brought about a revolution in traffic, causing such regions to be better developed industrially and commercially.

With regard to a closer coordination between rail and highway carriers, the Congress outlined three plans which may be followed. These involve voluntary cooperation between railroad companies and operators of motor-coaches and common-carrier trucks; inauguration of highway transport services by the railroad companies or participation by these companies in the conduct of highway transport undertakings; and a system of cooperative operation by the different transport companies whereby, in case agreement is not reached, governmental authority may be called upon to enforce compulsory coordination.

Another point brought out by the Congress was the desirability of appointing an international committee to consider uniform standards for traffic-control signals and other control devices.

Program Fills Entire Week

The Congress held last month in Washington was the sixth held by the Association. The five previous Congresses were all held on the European Continent, at intervals of about three years and always at the invitation of some government. The first was held in Paris in 1905, and subsequent ones respectively in Brussels, London, Seville and Milan. The World War interrupted the schedule of meetings in 1913, and no meeting was held until 1923, when the Congress convened in Seville. It is noteworthy that the Congresses are distinctly technical in character, not commercial.

The program of the Sixth Congress was arranged by the American Organizing Commission, under whose immediate direction it was held, to comply with the requirements of the agenda prepared by the Permanent International Commission of the Permanent International Association of Road Congresses. By appointment of President Hoover, Roy D. Chapin, formerly president of the National Automobile Chamber of Commerce, was named president, and T. H. MacDonald, chief of the United States Bureau of Roads, secretary-general of the American Organizing Commission.

The Sixth Congress was officially opened by the Hon. Henry L. Stimson, Secretary of State, who delivered the address of welcome on behalf of the Government of the United States. Secretary Stimson stressed the unselfish spirit of international cooperation exemplified in the Sixth International Road Congress and said that it is to such a spirit that we must look for the basic guarantees to the further peace and prosperity of the world.

Congress Composed of Two Sections

The Congress was divided into two sections, the first to study the subjects of construction and maintenance, and the second to undertake the solution of pressing problems of traffic and administration. Each section considered three main questions, and conclusions reached on these were later published in the Daily Bulletin of the Congress. The Daily Bulletin, consisting of about 20 pages, was printed in the four official Congress languages — French, Spanish, English and German — and carried Congress news as well as highlights of the discussions of the previous day.

The problem of making the speeches available to the delegates in four languages was met in the following way: The Congress members were seated together in groups according to the language they spoke. An interpreter translated the remarks of the speaker, in a low voice so as to avoid disturbance to the speaker, and the various translations were transmitted through head-phones attached to every member's chair. Thus, if a speaker were talking in French, an Englishman could "tune in" and hear the address only in English.

Questions Before Congress

The basis for discussion at the sessions was formed by 76 separate reports treating highway construction, design, material, maintenance, administration, finance and traffic. The specific questions proposed in connection with construction and maintenance were as follows:

(1) Results obtained by the use of (*a*) cement; (*b*) bricks or other artificial paving. (Methods employed for

road construction and maintenance in these materials)

(2) The most recent methods adopted for the use of tar, bitumen and asphalt in road construction

(3) The construction of roads in new countries, such as colonies and undeveloped regions.

The conclusions reached by the delegates regarding the first two questions concerned, for the most part, the physical properties of the materials and their adaptability for use in certain types of road construction. It was generally agreed, apropos of the third question, that it is desirable, first, to form a central body having legal authority to coordinate and assist the general planning of the road communications of a country and the acquisition or reservation of necessary land.

The second section of the Congress took up the following questions on traffic and administration:

(4) Ways and means of financing highways: (*a*) road construction; (*b*) maintenance

(5) Highway transport: Correlation and coordination with other methods of transport; adaptation to collective (organizations) and individual uses

(6) (*a*) Traffic regulation in large cities and their suburbs; traffic signals, design and layout of roads and adaptation to traffic requirements in built-up areas. (*b*) Parking and garaging of vehicles.

Regarding ways and means of financing highways, it was generally agreed that:

(1) The motor-vehicle, with increasing use, creates demand for large expenditures for reconstruction and improvement of existing highways to new standards, construction of new highways and effective maintenance of all improved highways. It justifies such expenditures through improved economy and efficiency of transportation, especially within areas previously served by highway transport and through extension of economic, commercial, and social access to new and wider areas.

(2) To meet the large financial problems involved and to secure the fullest and quickest benefits from the new form of transportation, it is specially important that highway programs covering a period of years be set up well in advance and carefully budgeted. Adjustments to meet changing conditions and improved methods can readily be made as developments may require.

(3) Provision for systematic maintenance of all highways after improvement is an essential feature of a sound highway program. If proper types of highways in relation to the character and volume of traffic are provided, maintenance costs should be less than with inadequate highways handling the same traffic.

(4) The cost of constructing, improving, and maintaining adequate highway systems should be distributed equitably in relation to the direct and indirect benefits derived, taking into consideration the taxable capacity of those benefited.

Highway Transport Discussed

The subject of the fifth question, highway transport, was of special interest to the automotive engineers in attendance at the Congress. The views of the Congress on this question were as follows:

(1) The coordination between different systems of transportation by land, by water, and by air should be so arranged that every transport should be done, as far as possible, through the most economical way and that most fitted to the particular needs. In this matter, the public authorities should adopt such legal and fiscal regulations as will not disturb the natural economic conditions of each transportation system.

(2) The coordination of rail and highway transportation is the more pressing problem.

(3) In general, private automobiles form the most important part of highway traffic and it is they which compete most seriously with the railways in passenger traffic. Railroads find it advantageous to substitute for unprofitable train buses operated by themselves or by others.

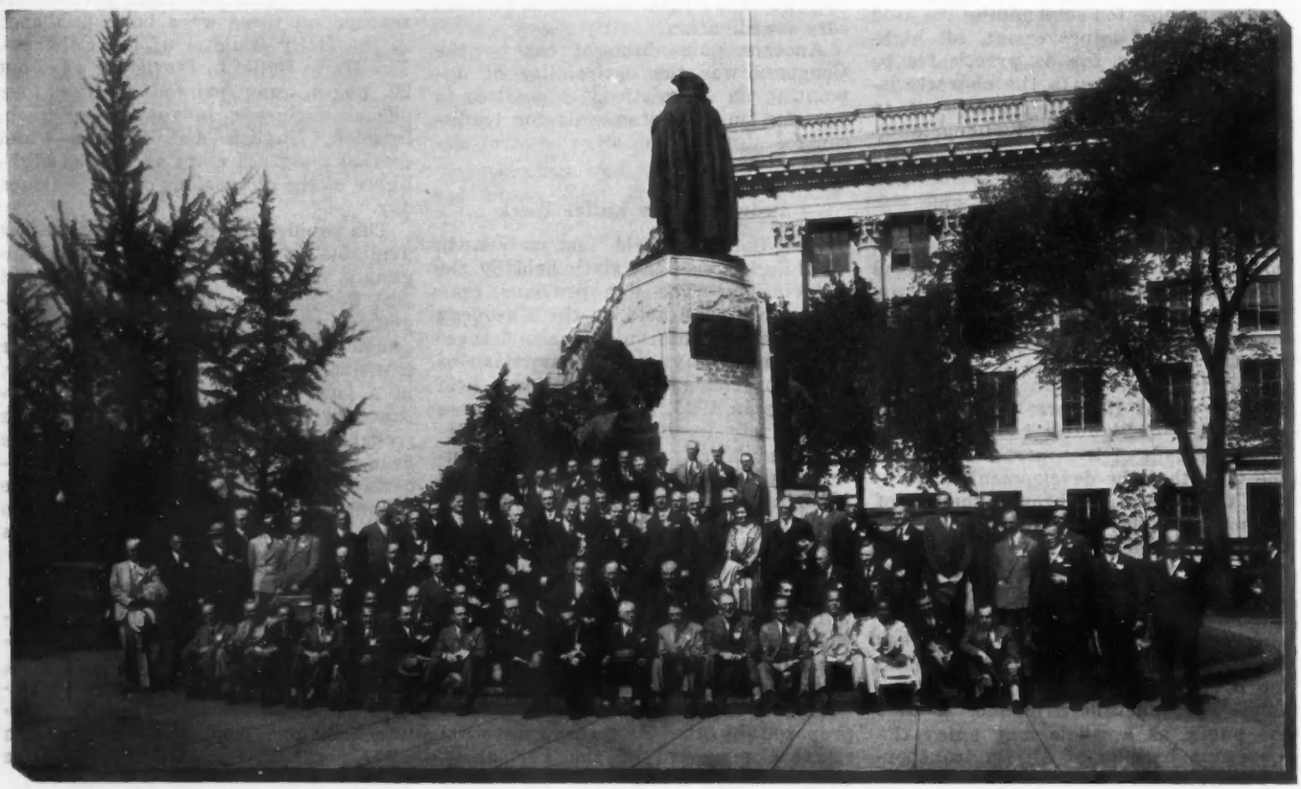


FIG. 1—DELEGATES FROM MANY COUNTRIES IN ATTENDANCE AT THE SIXTH INTERNATIONAL ROAD CONGRESS IN THE CITY OF WASHINGTON, OCT. 6 TO 11

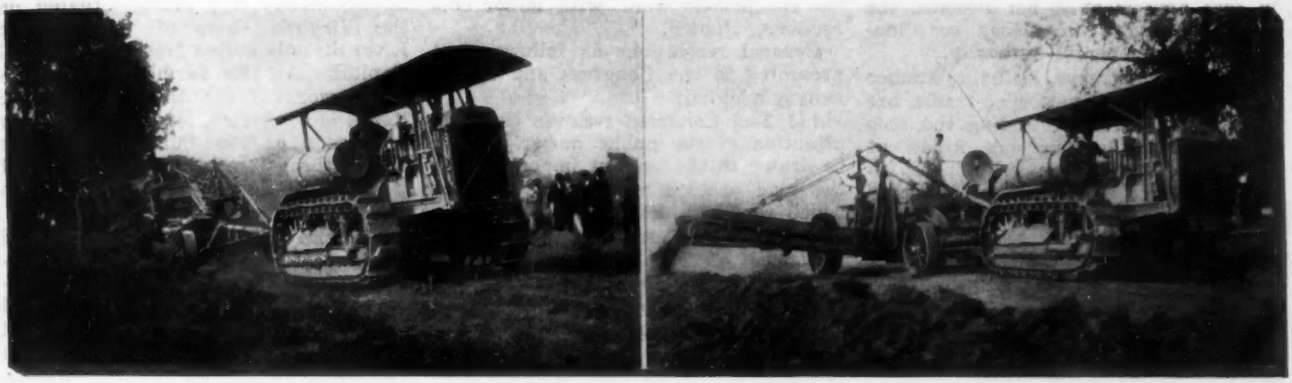
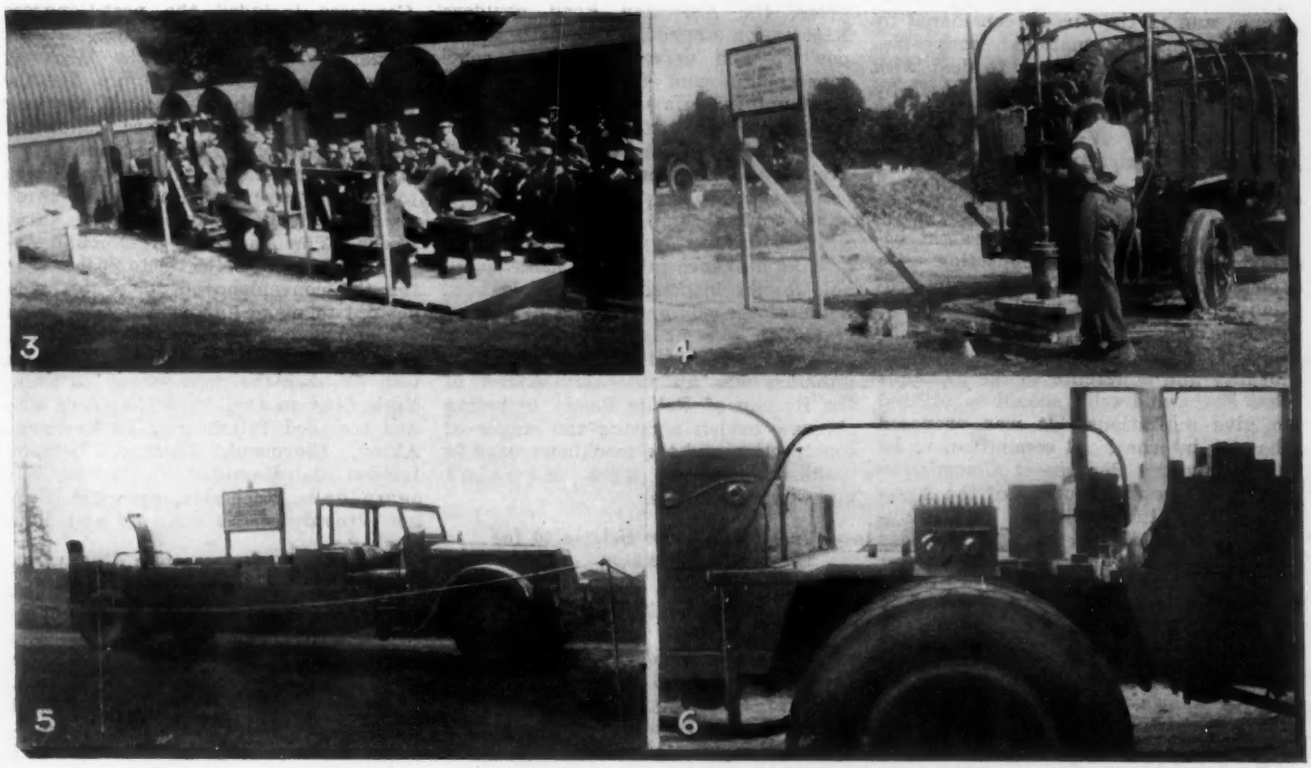


FIG. 2—SOME OF THE ROAD-CONSTRUCTION EQUIPMENT DEMONSTRATED BY THE AMERICAN ROAD BUILDERS ASSOCIATION

(4) The operation of all public motor-omnibus services, irrespective of ownership, must be subject to adequate control by a responsible authority embracing a wide area so as to assure regularity, efficiency, and adequacy of service, safety of the public at large, and avoidance of excessive competition and uneconomic fares.

(5) In considering the various proposals for a closer coordination between rail and highway carriers, one or more of the following three plans is usually followed: (*a*) voluntary cooperation between railroad companies on the one hand and operators of buses and common-carrier trucks on the other; (*b*) inauguration of highway transport services by the railroad companies or financial and administrative control or participation exercized by these companies in the conduct of highway transport undertakings; (*c*) quasi-legal coordination, with obligation placed on the different transport companies to agree to the creation of a system of cooperative operation and,



SOME OF THE EXHIBITS AT THE ARLINGTON EXPERIMENT STATION OF THE BUREAU OF PUBLIC ROADS

Fig. 3—Apparatus for Developing Laboratory Methods for Determining the Stability, or Field Behavior, of Different Types of Bituminous Mixtures. It Includes a Mixing Pan, a Molding Machine, a Roller Stability Machine and a Hubbard Field-Stability Machine

Fig. 5—Motor-Truck Equipped for Making Impact Investigations. These Are Conducted by the Bureau of Public Roads, under the Technical Direction of a Cooperative Committee Consisting of Representatives of the Bureau of Public Roads, the Rubber Association of America and the Society of Automotive Engineers, To Determine the Magnitude of the Impact Forces Exerted by Various Vehicles on Pavements and To Study the Factors Principally Responsible for These Forces

Fig. 4—Core-Drilling Machine Used for Obtaining Cylindrical Specimens from Concrete Pavements. Specimens Are Obtained Usually for Two Purposes: First, To Make Sure that the Pavement Is of the Required Thickness, and, Second, for Making Strength Tests of the Specimens

Fig. 6—Close-Up of Rear End of Truck Shown in Fig. 5, Showing Test Instruments

in case agreement is not reached, the enforcement of compulsory coordination by governmental authority.

(6) Traffic surveys, including studies of origin and destination of traffic, are of special value in revealing the true characteristics of various kinds of motor traffic and their relationship to other forms of transportation, whether as feeders thereto or supplementary thereof.

(7) Taxes for highway purposes should be borne not only by motor-vehicles but by all interests which benefit from the highway system, and should not be such as would arbitrarily prohibit the use of highways.

(8) Cooperation between railroads and automobiles, which has already been effected to some extent, is one of the great requirements of the age. In seeking such solutions, the need of aviation for the provision of airdromes and roads leading to them must not be overlooked.

A resolution was passed by the Congress to the effect that the question of establishing coordination and harmony between the various systems of transportation by road and by rail, by waterways, and in the air, be considered by the various international congresses that may be called upon to deal with it, and that reports be prepared by joint commissions of the accredited representatives of these various systems of transportation.

Traffic Regulation

The last question to be brought before the Congress in connection with the section on traffic and administration related to traffic regulation and the parking and garaging of vehicles. The Congress urged the necessity for uniformity and adherence to the principle that shape and color should be utilized to give indications. It was proposed that an international committee, to be named by the Permanent Commission and the Executive Bureau of the Association of International Road Congresses, should undertake to propose uniform standards for traffic-control signals and other control devices. The Congress believed that the passage of pedestrians across heavily traveled streets can be facilitated and protected through the construction of subways or bridges at street intersections or other natural places of crossing. Where traffic is not sufficiently heavy to warrant such structures, pedestrian traffic can be facilitated and protected by the use of definitely marked lanes at street intersections and other natural places of crossing.

The various conclusions mentioned in the foregoing paragraphs were presented before the Congress at the Plenary Session on Friday, Oct. 10, by the general reporters for the several questions. After due consideration the conclusions were, with minor corrections, adopted.

General resolutions as follows were presented to the Congress and unanimously adopted:

(1) The Congress resolves that the attention of the public powers should be drawn to the present importance of the road problem and the advantages which would be derived from devoting increasingly higher sums to the improvement of road systems.

(2) In order to supplement the efficient work being carried out by the Permanent International Commission of Road Congresses, the Sixth International Road Congress, held in Washington, resolves to request each of the governments represented in this Congress and adhering to the Permanent International Commission of Road Congresses in Paris to appoint a national commission which will cooperate with the Permanent International Commission in its important campaign for the improvement of roads throughout the world.

International Road Show Staged

Coincidental with the Road Congress, the American Road Builders' Association staged an international exposition and demonstration of road-construction and maintenance equipment and materials. Part of this was held in the Washington Auditorium, while road machinery in actual use was exhibited on a demonstration field. The exhibits of construction and maintenance equipment were varied each day so that various types of construction and maintenance might be made available for the inspection of the delegates. Some of the equipment shown is illustrated in accompanying photographs. Also on display in the Washington Auditorium was an extensive exhibit of the Bureau of Public Roads, including six new models showing the stages of construction and the machinery used in building different types of modern highway surfacings.

Inspection Trips Scheduled for Delegates

Three excursions of unusual interest and educational value took place during the Congress. A trip to Mount Vernon by motorcoach was made on Wednesday, Oct. 8. There the delegates to the Congress inspected the Mount Vernon Memorial Highway, the construction of which was authorized by an act of Congress in 1928, to celebrate the 200th anniversary of the birth of George Washington. The construction work is now under way and the Memorial Highway, when completed, will connect Mount Vernon with the south end of the Arlington Memorial bridge across the Potomac River.

The second excursion was to the Arlington Experiment Station of the United States Bureau of Public Roads, which comprises a total land area of approximately 400 acres, situated on the Virginia shore of the Potomac River directly across from the National Capital. At this farm the investigational work of the Bureau of Public Roads is conducted, leading to a better knowledge of road-building materials and methods for their use. Several of the exhibits at the Experiment Farm are shown herewith.

The third inspection trip was held on the last day of the Congress, Saturday, Oct. 11. At that time the members visited the United States Naval Academy at Annapolis. An important feature of this trip was a luncheon and reception for the delegates, given at the State House by Governor Ritchie, of Maryland.

Social Functions and Tours

The social calendar of the delegates during the Congress was crowded with important events. Receptions were extended to the delegates by President and Mrs. Hoover on Thursday, Oct. 9; by Secretary and Mrs. Stimson on Wednesday, Oct. 8, and by various foreign embassies and legations.

Other entertainment features of the Congress included the post-Congress tours arranged by various associations. Under the auspices of the Highway Education Board, three tours, for the purpose of first-hand study of highway transport conditions, were conducted through the South Atlantic States, New England and the Middle West. These tours, converging at Detroit for three or four days, occupied about three weeks. The American Automobile Association sponsored a motorcoach tour for the convenience of delegates who desired to make an inspection of some of the principal highways of the United States. The party left Washington on Oct. 12 and the tour ended in New York City on Oct. 28. The cities visited included Pittsburgh, Youngstown, Akron, Cleveland, Chicago, Detroit, London and Hamilton in Canada, Niagara Falls, Rochester, Syracuse, Boston, Providence, New Haven and New York.

The nationally recognized importance of the Sixth Road Congress held at Washington was evidenced by the number of large organizations that lent the prestige of their names to the Congress by consenting to serve as patrons. Automotive organizations included among these patrons were the American Automobile Association, National Automobile Chamber of Commerce, Society for the Promotion of Engineering Education and the Society of Automotive Engineers.

Appropriately enough, the motto of the Permanent International Association of Road Congresses is composed of two Latin words, meaning "The Highway Is Life." Highways, making possible all modes of motor transportation, are the media of a world-wide progress in commerce and art.

Operation and Maintenance Featured

(*Continued from p. 517*)

Works, Kansas City, Mo., stated in his prepared discussion that the methods of fabrication, shop practices, and design values set forth in Mr. Goll's paper have been strictly—and very successfully—adhered to in his plant for the last year in the fabrication of aluminum-alloy products. Any manufacturer following the methods outlined should have no trouble in fabricating, he continued.

A. F. Coleman described his experience with four aluminum tanks fabricated in two types. Two were of the separable compartment type; the other two were made up exactly along the lines of the regular steel-construction in that the wrapper sheet and the heads were welded together and there was a separate strap welded over the two compartments so that in reality they formed one tank. We have been watching those tanks in service for the last year with great interest, he continued, and have had no trouble from leaks from either construction, nor have we had any structural failure in the tank.

A. M. Wolf compared a steel body with an aluminum body and said that if one does not increase the payload, one gets the equivalent of putting in an engine having a 10.4 per cent greater tractive ability.

It was remarked by James E. Hale that tire manufacturers are more concerned about weights, or loads on the tires, than in any other characteristic of motor-vehicle operation. In his opinion there is a great opportunity to take this weight-saving capability of materials and present it in a great many forms. Other detailed discussion relating to the subjects already mentioned was continued at length.

Subjects treated in Lieut.-Col. Brainerd Taylor's paper included the organization of a theater of war, the coordinated transportation system of a theater of war, the organization of motor-transport in the United States Army, the echelonment of maintenance, and the unit-repair and replacement system. In his introduction he remarked that maintenance of motor-transport in the Army is functionally the same as is the maintenance of motor-transport in commerce; but war imposes conditions not encountered in commerce which require special organization, practices and administration and therefore peace-time planning and training. His presentation of the subject therefore was made with future war-time requirements in view, and in the hope that commercial advantages may be discovered in military thought and practice. His intent was to visualize war-time transportation in which the maintenance of motor-vehicles is an important factor that cannot be solved as an independent problem.

Using a chart showing the organization and supply methods in a theater of operations, Colonel Taylor explained the operation and maintenance of the motor-transport vehicles in detail, dividing them into five natural "echelons" or steps of maintenance in each

JOHN M. ORR
Chairman of Pittsburgh Section

of which there are three distinctively different elements—the personnel, the shop and tool equipment, and automotive supplies—and made detailed comment thereon. In conclusion, he called attention to the divergent requirements of commerce and war, regarding the use of highways, that need forethought and coordination in time of peace. He said also that these will materially affect maintenance in the Army, as well as having a direct effect commercially.

In prepared discussion, Brig.-Gen. F. H. Pope stated that Colonel Taylor's able and thorough discussion of the system of Army motor-transport maintenance expresses the mature views of the Army officers who have been intimately associated with military motor-transport since it became a factor in this Country's military service about 15 years ago. Continuing, he said that this subject of military transportation should be of especial concern at present to the automotive industry, for reasons of self-interest as well as for those that are sometimes erroneously believed to be of a disinterested or academic nature. Further, the Army is now giving special attention to the subject of mechanization, or the use of mechanized vehicles in combat. An experimental mechanized force has been organized that will be equipped with all the latest and most modern motor-transport equipment that the Army has on hand.

General Pope emphasized several points in which there may appear to be a variance between commercial and military requirements. First, he said, all industrial organizations are designed to produce an article that can be sold for profit. The production of a dividend is the basic principle in all industry and commerce. Therefore, the construction of a commercial vehicle, in design and in quality of material, is controlled in a very large degree by the exigencies of a highly competitive market. Motor-vehicles must be built to a price, and not to the ideal of an automotive designer. On the other hand, the exigencies of military operations preclude this condition. Certainty of action is one of the prime essentials for military success, and all other considerations must give way to certainty of action. Therefore a military vehicle must be built up to a standard and not down to a price.

Prepared discussion was submitted by Capt. Walter C. Thee, Q.M.C., of the Army. He stated in part that the paper covers more than Colonel Taylor actually claims. The scheme of maintenance is not only admirably applicable for combat, tactical supply, transportation and general-supply missions of the United States Army motor-transport, but also for the problem of operation and maintenance of commercial transportation. It will be necessary, however, to modify the interpretation of the five echelons of maintenance for commercial practice, according to the policies of different organizations. He then explained details of these modifications.

Pittsburgh Section Workers

INTEREST, enthusiasm and work—principally the last—by the members of the relatively young Pittsburgh Section under the leadership of the following personnel was very largely instrumental in making the Transportation Meeting at Pittsburgh one of the best ever held by the Society. Acknowl-

edgment is therefore made of their fine cooperation, and the Society hereby expresses its appreciation.

John M. Orr, Chairman; Miss Elizabeth Kenney, Assistant Secretary; Clyde C. Mathis, Chairman, Program Committee; B. H. Eaton, Vice-Chairman in charge of tickets and general arrangements; A. D. Tiel, Chairman, Reception Committee; C. R. Noll, Secretary, Publicity; Murray Fahnestock, Treasurer; N. G. Bjorck, Past Chairman; C. F. Kells, Chairman, Papers Committee; J. A. Harvey, Chairman, Members Committee; and Lee Hall.

Joint Committee Meeting Held

AT THE Joint Committee Meeting held on Wednesday evening, Oct. 22, while the Pittsburgh Transportation Meeting was in progress, those in attendance discussed tractor-trailer fifth-wheel standardization; two prospective sessions of the 1931 Annual Meeting—respectively, the Transportation and Maintenance, and the Motorcoach and Motor-Truck Activities; the uniform method of cost comparison proposed by L. V. Newton; and the mechanical information forms proposed by J. F. Winchester.

This was a joint meeting of representative members of the S.A.E. Transportation and Maintenance Activities Committee, of the S.A.E. Motorcoach and Motor-Truck Activities Committee, of the American Petroleum Institute, of the Trailer Manufacturers, and of the trailer fifth-wheel manufacturers.

Considerable progress was made in that, from the analyses presented in respect to the aforesaid subjects, a better understanding of the work done in the past was afforded and a more definite conception was given of the procedure which will be needed to carry these matters to a satisfactory conclusion.

F. C. Horner was chairman. Under his leadership several important decisions were reached in regard to the subjects already mentioned. It was decided to continue the work on standardization of fifth-wheel connections, for which the following subcommittee was formed to consider: P. P. Pierce, Chairman, P. Schon, R. B. Jones, G. W. Chamberlin, L. V. Newton, and M. C. Horine. This subcommittee plans to meet in Chicago on Nov. 13, 1930, at the time of the American Petroleum Institute Convention there.

The Transportation and Maintenance Activities Committee is developing further data relating to both comparative cost-accounting and mechanical information forms with the purpose of eventually presenting them to the Society with recommendations for their adoption as S.A.E. Recommended Practices.

Instructive Plant Inspections

A Service Station and an Aluminum-Body Factory Visited by 50 Members

DURING the course of the sightseeing and inspection trip made on Friday afternoon, Oct. 24, the 50 or more members especially interested in plant equipment were shown through the entire plant of the Equitable Auto Co., of which John M. Orr is general manager. All the equipment needed for maintaining motorcoaches was on view, the plant being divided into various departments to care for special classes of work. These include a stockroom, a machine shop, a forging and welding shop, engine-testing dynamometers, machinery and accessories for repairing transmissions, boring out new bearings, regrinding crankshafts, relining brakes, and the like.

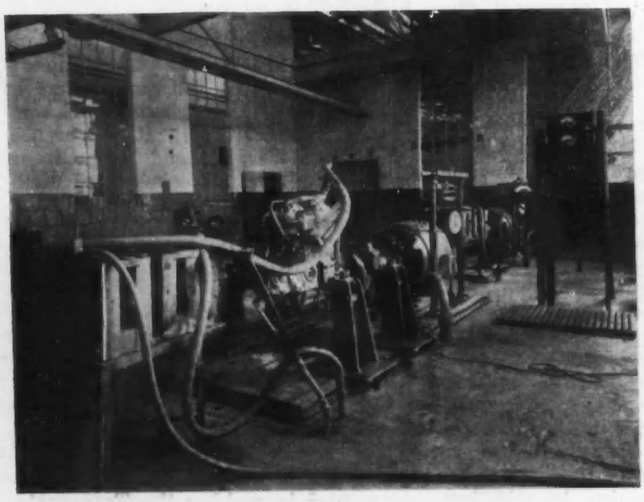
All oil used is reclaimed, and a complete oil-reclaiming plant is available. Lifts of several types are provided for raising and lowering motorcoaches from the floor level so that access is easy for repairmen who work underneath the vehicles. These are located at convenient points, and demonstrations were given as to how they operate. A brake-testing machine was also part of the shop equipment, and a separate department was devoted to electrical, carbureter, storage-battery and radiator repairs.

Work in this plant was in full swing and opportunity was afforded for the visitors to observe both the general and the specific methods used.

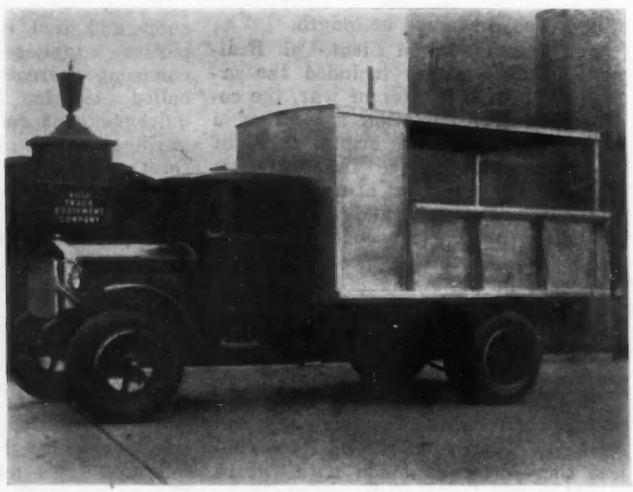
Aluminum-Body Construction

A. M. Hauber, president of the Auto Truck Equipment Co., personally demonstrated a high-lift coal-carrying aluminum dump-body which has already withstood two years of service with but little wear; perhaps with less wear than a steel body would have shown in the same length of time. The successful operation of this type of body has caused other companies in the same line of business to adopt aluminum bodies.

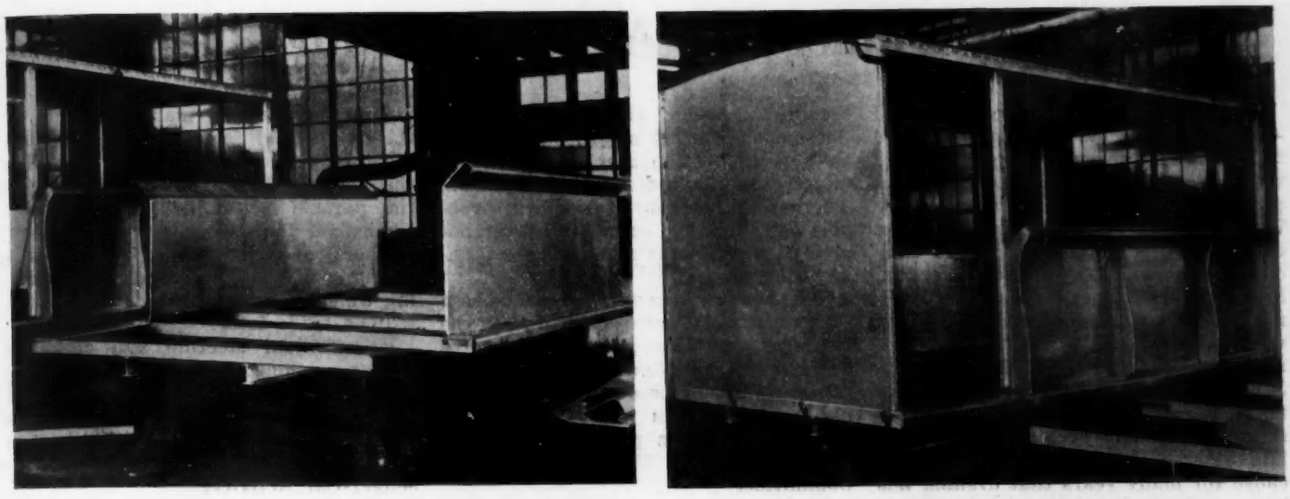
Mr. Hauber personally conducted the visitors through his plant, where workmen were engaged in constructing and assembling aluminum bodies of various types. One interesting machine was a large press for bending sheet alum-



DYNAMOMETER AND ENGINE-TESTING LABORATORIES OF THE EQUITABLE AUTO CO., PITTSBURGH



ALUMINUM BODY MADE BY THE AUTO TRUCK EQUIPMENT CO., PITTSBURGH



TWO TYPES OF ALUMINUM BODY UNDER CONSTRUCTION AS PRACTISED BY THE AUTO TRUCK EQUIPMENT CO.

inum, and a demonstration was given of its operation. A carpenter shop and other special features were noted also. While describing various aluminum bodies in process of construction, Mr. Hauber quoted many interesting figures illustrative of the difference in weight of bodies constructed of aluminum and those constructed of steel. All the visitors were greatly interested in both the plants mentioned and many expressed their thanks to Mr. Orr and to Mr. Hauber for the privileges and courtesies of which they had been the recipients

ORDERLY ARRANGEMENT OF STOCK IN THE PLANT OF THE EQUITABLE AUTO CO.

Annual Dinner and Annual Meeting Plans

ABOUT two months hence the eyes of the automobile industry will be turned toward New York City, where the 1931 Automobile Show will be in progress. As in former years, Show Week will comprise so many events that everyone attending will find his time completely occupied. It seems certain, however, that every automotive engineer in New York City that week will want to attend the S.A.E. Annual Dinner scheduled for Thursday evening, Jan. 8. In fact, it has become customary for members of the Society to reserve Thursday evening of Automobile Show Week well in advance, because for many years that evening has been set aside for the Society's Annual Dinner, the one general and truly social event on the S.A.E. calendar.

The Hotel Pennsylvania, which catered last year's dinner, has been chosen again for the 1931 Annual Dinner.

The Annual Dinner Committee, composed of Chairman W. T. Fishleigh, F. K. Glynn and B. J. Lemon, is perfecting plans for the occasion and will make an announcement at an early date regarding the program.

Extensive Annual Meeting Program

Fifteen technical sessions and a dinner go to make up the ambitious program laid out by the Meetings Committee and the Professional Activities Committees to fill Annual Meeting week, Jan. 19 to 23, in Detroit.

Tentative plans indicate that the first technical session will be an Engine Session on Monday afternoon, followed by a Body Session that evening. Two papers are planned for the afternoon, whereas the evening session will probably be confined to one paper. A Standards Session also is scheduled for Monday afternoon.

Tuesday morning will be devoted to a Fuel Research Session, sponsored by the Research Committee; the afternoon, to a discussion of fuels and lubricants, and the evening will see the gathering of production men in great numbers to attend the session provided especially for them by the Production Activity Committee.

Wednesday morning will be a very busy time, as two sessions are to be held concurrently. One of these will be devoted to a symposium on the subject of detonation; the other to transportation problems. In the afternoon, a Motor-Truck and Motorcoach Session will be held. The Aircraft Activity has provided a program for Wednesday evening on a topic that will be of interest to almost everyone who attends the Annual Meeting.

Again on Thursday morning the interest of the members will be divided, as some will attend the Aircraft-Engine Session, whereas others will want to hear the papers that are to be given at the Chassis Session. The first of two Diesel-Engine Sessions will be staged on Thursday afternoon, and a lively discussion is anticipated.

Thursday evening marks the date of the only social feature of the Annual Meeting, namely, the dinner, at which the Detroit Section, cooperating with the parent Society, will act as host. Chairman Phil Kent and his fellow workers of the Detroit Section are planning a splendid program, concerning which more detailed announcements will be made later.

The Annual Meeting will close on Friday morning, Jan. 23, with two simultaneous sessions. One of these will be a Diesel-Engine Session and the other a General-Development Session of broad interest sponsored by the Passenger-Car Activity.

All of the eight Professional Activities are participating in the Annual Meeting; hence it is believed that the program, which is rapidly assuming its final form, will appeal to every member of the Society, whatever his particular line of work. Information regarding the papers and speeches will appear in the December and January issues of THE JOURNAL and in Meetings Bulletins.

As many as possible of the papers will be preprinted, so that members who desire to read a paper in advance of the meeting with a view to entering into the discussion may do so. An opportunity will be given all members, prior to the meeting, to indicate the papers that they wish to receive; and copies, when available, will be sent to those requesting them.

Stanley W. Mills

AFTER an illness extending over a period of more than eight months, Stanley W. Mills, veteran Pierce-Arrow engineer, passed away on Aug. 28 at his home in Buffalo. His loss is keenly felt by the host of friends he had made in the manufacturing organization.

Born in Leicester, England, in December, 1881, and educated in the schools of England, he acquired his early training in that country, where, after a three-year technical course, he became an apprentice with Taylor & Hubbard, engineers, of Leicester. He steadily improved his position and subsequently served as draftsman for this firm and for the British United Show Machine Co. and the Coventry Ordnance Co., of Coventry.

Coming to the United States in his early manhood, Mr. Mills' next position was with the Cadillac Motor Car Co., of Detroit, which he joined as draftsman in 1906. In 1908 he became a draftsman and checker for the Burroughs Adding Machine Co., of the same city, and from 1909 to 1912 was chief tool designer for the Fiat Automobile Co., of Poughkeepsie, N. Y., which then promoted him to the position of assistant to the chief engineer and gave him complete charge of drafting, tool designing and inspection. In 1917 he accepted a position with the Highway Tractor Co., of Indianapolis, as chief engineer, but shortly thereafter joined the Pierce-Arrow Motor Car Co. as assistant to the chief truck engineer. Not long afterward he was promoted to chief truck engineer and in 1929 was transferred to the passenger-car division of that company as chassis engineer. He was mainly responsible for the introduction of dual valves in Pierce-Arrow truck engines.

Mr. Mills was elected to Member grade in the Society in January, 1918. He was an active participant in the affairs of the Society, having been Vice-Chairman of the Motorcoach Division of the Standards Committee for the three years from 1926 to 1929, and a member of the Motor Truck Division of the Standards Committee in 1928 and 1929.

Council Appoints Military Committee

THE OCTOBER Council meeting, which was held in Detroit on Oct. 9, was attended by President Warner, Vice-Presidents Davis, McCain and Younger, Councilors Fishleigh, Moyer, Parker and Teetor, Past-President Strickland, Treasurer Whittelsey and Secretary Warner; Chairman Beecroft and J. W. White, of the Finance Committee, Chairman Boor of the Standards Committee, Chairman P. J. Kent, of the Detroit Section, and Standards Department Manager Burnett.

The Council considered the request of the Quartermaster General that a Military Motor Transport Advisory Committee be organized in the Society to consider broad questions of military transportation in which the automotive industry is concerned and to advise the Quartermaster Corps and the industry alike as to practices, standards, practical means of coordination of conflicting requirements and other matters connected with military motor transport of National importance. Accordingly, the Council appointed the following to serve as members of this committee: B. B. Bachman, W. J. Davidson, W. T. Fishleigh, G. A. Green, J. E. Hale, A. W. Herrington, F. C. Horner, H. L. Horning, A. F. Masury, G. L. McCain, O. A. Parker, D. G. Roos, A. J. Scaife, A. W. Scarratt and J. F. Winchester.

Councilor Parker proposed that the following amendment be made to the Society's By-Laws, to cover the appointment of an Assistant General Manager, a position which was created by the Council of the Society at its meeting held in New York City on July 8, 1930:

B-32a—The Secretary and General Manager, after his appointment at the first Council meeting after the Annual Meeting of the Society, shall, with the approval of the Council, appoint an Assistant General Manager of the Society.

This proposed amendment will be voted upon at the next regular meeting of the Council.

Seventy-two applications for individual membership were approved, together with seven transfers in grade of membership and two reinstatements. Twelve resignations were accepted and three members were stricken from the rolls of the Society for non-payment of dues.

A financial statement as of Aug. 31, 1930, was submitted and approved. This statement showed a net balance of assets over liabilities of $244,773.02, this being $20,088.69 more than the corresponding figure on the same date of 1929. Gross income of the Society for the first eleven months of the past fiscal year amounted to $403,050.77, and the operating expense was $388,042.61. Income for the month of August, 1930, was $30,780.47, and the operating expense $30,276.65.

The budget of expenses for the fiscal year, beginning Oct. 1, 1930, was approved, this having been submitted, together with an estimate, by the Finance Committee for adoption.

The Council considered detail budget figures submitted by the various Sections and voted to approve these budgets with certain revisions that were deemed advisable.

Production Activities Considered

Committee Decides on Annual Meeting Session Program—Spring Production Meeting Planned

MEMBERS of the Production Activity Committee of the Society held a meeting in Detroit on Oct. 7, during the National Production Meeting there, at which several important topics were discussed. The principal decision arrived at was the program for the Production Session at the Annual Meeting to be held in Detroit next Jan. 19 to 23. The subject to be presented and discussed at that session is, Controlling Factors in Machine-Tool Obsolescence, the co-authors of which are L. A. Blackburn, of the Oakland Motor Car Co.; J. W. Brussel, of the Timken-Detroit Axle Co.; and A. R. Fors, of the Continental Motors Corp. It is planned that preprints of the paper will be available for review in preparation of scheduled discussion well in advance of presentation of the paper at the meeting.

Plans are also under consideration for holding a spring Production Meeting, preferably in April, 1931, regarding which more information will be published later.

One of the important subjects in progress is the preparation of an up-to-date bibliography of production papers and articles published by the Society, which the Committee is planning to incorporate in a descriptive pamphlet of the Production Activity of the Society and its work, for general distribution. The Committee feels that the Production Activity of the Society can accomplish much of value to production engineers and executives generally and that a pamphlet giving a brief description of these activities will be very useful in acquainting the manufacturing industries with the work of the Society and what it can accomplish for the manufacturing fraternity.

Members of the Committee who were present at the meeting are Chairman John Younger; Vice-Chairman J. W. Brussel; Meetings Committee Chairman J. Geschelin; W. W. Nichols, Erik Oberg, V. P. Rumely, General Manager John A. C. Warner and R. S. Burnett, Production Activity Director. N. H. Blank, of the White Motor Co., and A. P. Brush, of the Brush Engineering Association, were guests.

Standardization Progress

(*Concluded from p. 605*)

tolerances will become most common commercially.

To enable the Sectional Committee and the sponsors to know that the proposed standards are practical and acceptable to industry for all ordinary uses, the accompanying report should be carefully studied and criticisms sent to the Standards Department of the Society at 29 West 39th Street, New York City, as promptly as possible. Such comments will be referred to the Sectional Committee for consideration by it before submitting the report to the sponsors and the American Standards Association.

Transposition of Names

IN PUTTING the October issue of the S.A.E. JOURNAL to press, a mistake in the printing plant resulted in a last-minute transposition of the names of C. H. Biddlecombe and J. C. Hunsaker under their portraits on p. 464 in the discussion on Giuseppe M. Bellanca's paper on the Amphibian. This is regretted even though we are sure that neither of the good-natured gentlemen will take any offense and despite the adage that "mistakes will happen in the best regulated families." An apology is offered to Mr. Biddlecombe and Mr. Hunsaker with this correction. Any reader who does not know both of these men by name and sight will please read Mr. Hunsaker's name as applying to his portrait on the left and Mr. Biddlecombe's under the portrait on the right.

News of Section Meetings

(*Continued from p. 527*)

210 deg. The oil thus treated seems to possess lubricating qualities superior to even those of a high-grade mineral-castor oil.

Professor Baender next discussed what happens to the oil in an engine, such as carbonization on the under side of overheated pistons, contamination by dust and metal particles, dilution by unburned heavy ends of the fuel, and the formation of sludge. It is a curious fact, he said, that it is impossible to burn oil that is against the cylinder-wall provided the water-jacket is filled with water; experimental evidence is available that proves that the oil-film layer next to the cylinder-wall, which is about 1/40 in. thick, is at approximately the temperature of the water. Hence any oil that has fire and flash-points around 400 deg. fahr. should be immune from cracking and burning.

Restored Oil Better than New

The speaker showed himself to be in agreement with other investigators when he stated that, if the contaminations are entirely removed from crankcase drainings and the remaining oil is properly treated to restore the viscosity, fire and flash points, freedom from acidity and carbon residue, and so on, the resulting restored oil will be an even more perfect lubricant than new oil. The reason, he said, is that it will be free from the molecules that crack against the hot pistons, and also the unsaturated hydrocarbons. No refining company, he said, can refine an oil as perfectly as can an engine, and we can well say that a properly reclaimed oil is, in reality, a super-refined oil. A rather interesting fact is that reclaimed oil has a higher viscosity at 210 deg. fahr. than the original oil had, even though both may have the same at 100 deg. The speaker declared that, to be properly reclaimed, an oil must have restored to it every property it had when new, poth physical and chemical.

Disagreement was expressed with the theory that, because crankcase oil reaches stable dilution after 180 to 200 miles of operation, amounting to 10 to 15 per cent in the summer and 25 to 40 per cent in winter operation, it is better to use a prediluted oil and eliminate danger of under-lubrication with a heavy oil that will be too viscous to flow readily when starting a cold engine.

Regarding the cost of reclaiming oil, Professor Baender stated that with a plant making 3000 gal. per 24 hr. the total cost of finished oil is about 12 cents per gal., including a charge of 5 cents per gal. for the waste oil and all operating and overhead expenses. An interesting by-product of reclaimed oil is lubricating grease, which contains 99 per cent of pure mineral oil and is of pleasing color, odorless and of uniform consistency.

Outboard-Engine Progress Reviewed

Milwaukee Section Told of Improvements in Service and Racing Models

APPROXIMATELY 90 members and guests of the Milwaukee Section attended the first meeting of the season, which was held Wednesday, Oct. 1, at the Milwaukee Athletic Club, and about 45 members and guests attended the dinner and the entertainment by two entertainers from the *Milwaukee Journal* radio station preceding the meeting.

Keen interest was shown in a paper on The Development of Outboard Engines, which had been prepared by F. T. Irgens, chief engineer, and W. J. Webb, sales manager, of the Outboard Motors Corp. Mr. Webb read the paper and Mr. Irgens answered questions regarding various features of modern outboard-engine design and construction.

The paper traced the development of the outboard engine during a period of 30 or 40 years, the first model on record being a single-cylinder steam engine clamped to the back of a square-stern flat-bottom boat. Next came an electric outboard motor of French origin, followed in 1902 by a French engine that operated on gas. In 1906 an American engine builder developed a large, heavy, single-cylinder engine for driving heavy barges and lighters, and in 1909 Ole Evinrude developed the first successful outboard engine of the general type that we know today. This was a single-cylinder two-port two-cycle battery-ignited engine that developed 1½ hp. at 1000 r.p.m. It weighed about 50 lb.

The remainder of the paper dealt with refinements and improvements made since that time, in which the horsepower per cubic inch has been increased to five or six times its former value. The authors also pointed out how engine speed has increased from approximately 1000 r.p.m. up to 6000 or 7000 r.p.m. in present racing-type engines, while boat speeds have increased from less than 10 to more than 50 m.p.h.

Questions Bring More Facts

Following the delivery of the paper by Mr. Webb, many questions on the subject were asked by members and answered by Mr. Irgens. Most of the interrogating was done by W. F. Krenzke, of the Jacobsen Mfg. Co., of Racine, Wis.; Robert L. Dick, of the Wisconsin Motor Co., of Milwaukee; and Chester S. Ricker, of Day-Nite, Inc., of Waukesha, Wis. Questions were propounded also by E. L. Kullman, of the Wadhams Oil Co.; H. L. Debbink, of the Milwaukee Electric Railway & Light Co.; W. L. Pusey, of SKF Industries; R. W. Wilson, of the Perfex Corp.; and several others.

Answers given to the questions brought out supplemental information that the compression ratio is 10:1 in the racing engines but in the regular-production engine is 5 or 6:1, while the crankcase compression is from 4 to 5 lb. per sq. in.; that the two-cycle principle is used because of simplicity and lightness; that the lubricating oil is mixed with the liquid gasoline in the proportion of 1 qt. to 1 gal. for racing and less oil for general service; that the speed of piston travel is relatively slow even at engine speeds of 6500 to 7000 r.p.m. because of the short stroke, and the limiting factor in engine speed is the volumetric efficiency; that in general service the fuel consumption is about 1 to 1¼ lb. per b-hp-hr.; that, to get more power, additional cylinders rather than larger ones are used because large pistons are hard to cool and the heads burn, iron pistons burning worse than alloy pistons; that the piston-ring wall pressure is from 4 to 5 lb., as it must be low to allow the ring to pass the ports; that journal bearings are usually of the plain type or a combination of plain and antifriction bearings, but roller-bearings are used at the connecting-rod big end in racing engines; that straight bevel gears are used to drive the propeller shaft; that as few different alloys are used as possible to avoid electrolysis; and that rotary engines are fastest, with the three-port-type second.

Jardine Discourses on Valves

Tells St. Louis Section About Problems Encountered and Their Solution

VALVE problems and their solution provided the substance of a most able and practical treatise presented at the first meeting this season of the St. Louis Section by Robert Jardine, of the Wilcox-Rich Tool Co. The meeting was held at the American Annex Hotel on Oct. 14. Supper was served to 37 members and guests at 6:30 p.m., and nearly a score more came later to listen to the speaker. So widespread was interest in the subject that among those present were members of the engineering staffs of the local companies engaged in the manufacture of Diesel engines. The thoroughness of the paper and the lateness of the hour at its conclusion precluded prolonged general discussion of the subject, but Mr. Jardine answered numerous questions put to him by interested groups.

Valve Problems and Solutions

The speaker's paper covered the subject of valves and valve ports from the beginning and listed the early troubles experienced by internal-combustion-engine builders and the remedies evolved for them. The earliest valves used were made of plain carbon steel, he said, and were satisfactory only on the inlet side of the engine. The exhaust valves, exposed to the sweep of the hot gases, would burn, warp, mushroom, and do all the things valves were not supposed to do. The next step was to introduce exhaust valves made of almost pure nickel. These were somewhat more satisfactory than the plain valves, but they gave way to a composite valve made with a cast-iron head and a steel stem. From that time to the present, various combinations of tungsten, silicon, chromium, cobalt, aluminum, and other metals have been alloyed with iron to produce valves that will withstand the extremely high temperatures encountered. Every day brings new developments, each being more satisfactory than its predecessor, and it is hard to predict the ultimate solution of the problem.

While outwardly a simple problem, the manufacture of a valve presents difficulties that are perhaps unsuspected by the layman. The temperature of forging, the forging process itself, the search for defective material and workmanship, the subsequent analysis and remedy thereof, the design of valves for a particular service are all part of a highly specialized industry.

Oil and Salt-Cooled Valves

Having a suitable steel and a satisfactory method of forming valves without defects of material and workmanship, the designer is faced with the problem of meeting unusual service conditions and improving the performance. As the cooling of valves is a prime consideration for heavy-duty operation, the valve engineers, said the speaker, have introduced two satisfactory cooling arrangements. The first of these is a hollow-stem valve cooled by oil forced through the tappet, involving practically no engine complications when compared with the water-cooled valves of large engines. An even simpler method of carrying heat away from the head is the use of hollow stems containing metallic sodium, or salt, held in the stem by a plug at the end, for airplane work, and welded for motorcoach or passenger-car service.

Valve seats and valve ports must also have consideration. The valve guides must be placed so that they do not receive an undue amount of heat from the exhaust gases, and must be well cooled and properly located to resist carbon particles clogging the clearance space between the stem and guide. The seats also must be well cooled and located in the cylinder where the warpage will be minimized. The valve-port areas should be proportioned to provide uniform gas velocity through them, eliminating eddies in the gas stream.

Automotive Diesel Engines

Application to Trucks and Rail-Cars Discussed at Chicago Section Meeting

REGULAR monthly meetings of the Chicago Section were renewed for the present season on Oct. 7, with a dinner at the Sherman Hotel, followed by a technical session devoted to Diesel engines. Harte Cooke, engineer of the McIntosh & Seymour Corp., of Auburn, N. Y.; and F. E. Wynne, manager of the railway equipment department of the Westinghouse Electric Mfg. Co., of East Pittsburgh, Pa., were the two speakers.

The meeting was characterized by a large attendance of guests, 67 being present in a total of 116. During the progress of the dinner, entertainment de luxe was provided by the committee in charge. A xylophonist furnished music which was greatly enjoyed, as were several contralto solos given by Miss Jackson. Not to mention the antics of the highly trained, domesticated mule and its handler would be an injustice. Engineers present commented on the fact that this was undoubtedly the first mule that was perfectly at home on a banquet table.

In opening the program, Section Chairman E. W. Stewart extended greetings to the members and guests. A communication from John A. C. Warner, General Manager of the Society, was read and an announcement of the year's probable program was made. Chairman Stewart then introduced Harte Cooke, the first speaker of the evening.

Diesels Suitable for Trucks

Mr. Cooke's subject was Diesel Engines, in the development of which he has taken an active part. He pointed out that the present Diesel engine is an outgrowth of the gasoline engine and that its present success is due in a large measure to the perfecting of auxiliary equipment necessary to it. This equipment has, in reality, made the Diesel engine practicable. The high compression of the Diesel engine means economy because of comparatively high engine-temperatures and consequently high efficiency.

Although most of the Diesel engines used up to the present time have been stationary or used in rail-cars, considerable experimental work has been done with smaller Diesel units. Their application to trucks is a field in which activity may be expected. Trucks require powerful engines and are in use for comparatively long periods day and night, hence fuel cost becomes an item of great importance. It is here that the Diesel engine enters the picture because of its economy of operation. It is characteristic of engines of this sort that they must be of sturdy construction. They also require a fuel pump that will deliver accurate quantities of fuel under such pressure that it is broken into extremely small particles to aid in prompt ignition. The time period in small automotive Diesel engines is very short. Thorough mixing of air with fuel is necessary for effective combustion. In certain Diesel units turbulence is secured through design which imparts a whirling motion to the air within the cylinders.

Mr. Cooke pointed out that there are really three theories regarding fuel valves; first, that springs should govern the opening of the valves; second, that the valves should open mechanically; and, third, that no valves should be used, the oil being injected.

The address was concluded with the

showing of a series of slides illustrating many Diesel installations in various types of rail-car and the placing of the auxiliary equipment necessary to their successful operation.

Why Diesel-Engined Rail-Cars?

Mr. Wynne stated that his major attempt would be to point out reasons why Diesel engines are used on rail-cars. He said that the railroads must use every means at their command to hold their passenger and freight traffic and to increase it wherever possible. Competition from motorcoaches and trucks is becoming noticeable because of their ability to render prompt service at relatively short intervals. Oil-electric cars are now being used on branch lines to speed up service and are showing a profit or at least greatly reducing operating losses as compared with steam-locomotive traction for the same purpose.

Other features of Diesel-equipped rail-cars are quietness of operation and absence of smoke and dirt. The elimination of locomotives on branch lines and the substitution of rail-cars reduces the per-mile operating costs materially and gives most satisfactory service. On rail-car trains, the train weight is reduced, costs are lowered through use of cheap fuel, the Diesel engines operate with great thermal efficiency and fuel is used only when the train is in operation. Even though the first cost of Diesel-engined rail-cars is high, the cost of operating of the train is governed by hours of use, and most of the rail-cars are operated at a high maximum of time-efficiency. It is also of interest to the railroads, continued Mr. Wynne, that fuel oil is easily obtainable and can be stored at less expense than coal can be kept on hand at coaling stations. Coaling equipment is expensive.

Many four, five, and six-car main-line local trains will probably be supplanted by Diesel-equipped rail-cars, predicted Mr. Wynne. This is a fertile and as yet little explored field in railroad economy.

Diesel switching locomotives are proving popular, as they are easily handled, smooth in operation and controlled with the minimum number of jolts, shocks and jars, especially when equipped with electric transmission.

Many types and kinds of oil-electric rail-cars were shown in lantern slides at the conclusion of the address.

Questions Show Active Interest

A general discussion followed, in which active interest was displayed by those in attendance. The more pertinent of the questions and answers were as follows:

QUESTION:—What is the future of the hydraulic clutch in connection with Diesel locomotives?

HARTE COOKE:—Experiments both in this Country and abroad have been carried out on this type of clutch, but for the most part have been discontinued. Electric drive has proved far more efficient.

QUESTION:—Is a Bosch combustion system used on the new engine developed by your company?

MR. COOKE:—No, we used our own. It is not a pre-combustion type but a direct-injection type.

QUESTION:—Has your company done any work on installing 100 or 150-hp. Diesel units on motorcoaches?

MR. COOKE:—No, we have done nothing on that.

QUESTION:—What proportion of power of the Diesel engine is lost in cooling?

MR. COOKE:—That depends upon conditions encountered in designing the engine and locomotive as a whole, as space is at a premium on a locomotive of any type. Therefore the frontal area of the radiators may vary. Fan efficiency thus increases or decreases according to the conditions encountered in design.

Land and Air Traffic

Jacobs and Jacobs Give Pittsburgh Section Their Views on Road Safety and Airships

AT THE meeting held by the Pittsburgh Section on Sept. 24, the 125 members and guests who attended were informed by Section Chairman John M. Orr, of the Equitable Auto Co., regarding coming events in that city, including the National Transportation Meeting, details of which are reported in this issue of the S.A.E. JOURNAL.

H. V. Thaden, of the Pittsburgh Metal Airplane Co., acted as toastmaster at the dinner and introduced the two speakers, who bear the same surname and spoke in alphabetical order of their respective initials. They were H. D. Jacobs, editor-in-chief of the *Pittsburgh Press*, and V. R. Jacobs, assistant manager of the aeronautics department of the Goodyear Tire & Rubber Co. The former dealt with traffic congestion in Pittsburgh and the latter with air transportation by means of dirigibles. A. J. Scaife, of the White Co., spoke on the history of the Society and the advantages of membership therein.

According to Editor Jacobs, the automobile has entirely destroyed the centuries-old conception of what a city should be, for it has produced so great a traffic congestion that engineers are beginning to predict that our cities must be almost entirely rebuilt. Forty-foot streets will have to give way, he said, to thoroughfares four or five times that width, and there must be less concentration of office space. The skyscraper and the automobile are enemies and it now seems certain that, if one is to give way in the future, it will be the skyscraper.

But there is another angle to congestion. Nobody will deny, believes Mr. Jacobs, that the modern automobile is the most deadly weapon ever produced. It kills or injures, in this Country, more people in the course of a year than all the wars, pestilences and catastrophes whereof we have any record, he asserted. Although automotive engineers make cars mechanically safer from year to year by improving engines, steering-gears and brakes, this process seems only to lead many drivers to become more reckless than ever.

Unfit Drivers on the Road

Having talked with traffic officials and mental experts on this subject, the speaker said he is convinced that, if a universal mental test could be required, four out of five drivers would be forced off the thoroughfares. "You have probably read," said Mr. Jacobs, "of the traffic judge in Evanston, Ill., who has instituted mental tests for chronic offenders, conducted by psychological experts of Northwestern University. A boy of 19, arrested the fourth time for reckless driving, was found to have the mental age of 8½ years.

"I suggest that the next time you go driving, you make a mental list of all traffic-law infractions witnessed between your home and your destination. The result will amaze you. You might also observe your own mental tendencies to violate some of the laws of safe driving. Without expecting you to become traffic cops or monitors or the like, you can greatly help, by using your personal and collective influence, in solving the problems of traffic congestion and of reckless driving."

V. R. Jacobs, of the Goodyear organization, remarked that airplane and dirigible are not direct competitors; while the airplane helps to knit distant sections of this Country closer together, the lighter-than-air craft links continents and helps to create better understanding and peace among nations. He mentioned that America, most peace-loving of nations, has a natural monopoly on helium, which is essential for safe dirigible operation. It is estimated that, even though 10,000,000 cu. ft. annually were used, our resources would not become exhausted for 700 years.

The Los Angeles, continued the

speaker, has made people marvel at its size—2,700,000-cu. ft. capacity—yet the new Navy airships, now under construction at Akron, will each have a capacity of 6,500,00 cu. ft. This is by no means the practical limit of size, for present materials make possible the building of airships, with ever-increasing efficiency, of 15,000,000 cu. ft. That dirigible builders share this confident view is indicated, according to Mr. Jacobs, by their designing of hangars large enough for ships of 10,000,000-cu. ft. capacity.

"Unique features included in the two new dirigibles now being built," continued Mr. Jacobs, "include a compartment in which five Navy airplanes will be carried. When one of these planes is to be launched, it is hooked to an inverted T-bar within the ship. Then a trap-door is opened, the T-bar with the airplane attached is swung down, the engine of the plane is started and the airplane dropped off. And it is then up to the aviator—at a height of about 3000 ft., the altitude at which these maneuvers are expected to be carried out.

"Another feature of the new dirigibles is the complete housing of engines within the airship instead of being carried in nacelles or other extraneous compartments attached to the ship, thus reducing parasitic drag. Carrying the engines within the ships makes possible ample room for inspection and adjustment of the engines while in flight, assuring more reliable operation; in fact, the contract with the Navy includes a clause that a non-stop flight of 10,000 miles must be made at the rate of 50 m.p.h."

Roos Tells Pineapple Story

Takes Met. Section Free-Wheeling in Pictures and Words —Much Discussion Evoked

"LET'S GO free-wheeling" was the slogan of Metropolitan Section on Thursday evening, Oct. 16, when over 200 members and guests listened to Delmar G. Roos, chief engineer of the Studebaker Corp. of America, tell about the development and application of Studebaker's new species of "pineapple."

The story of the pineapple was preceded, however, by the introduction of John A. C. Warner, General Manager of the Society, who, after a brief and humorous greeting, closed with the remark, "You must now allow me to emulate the example of the bee. You know the bee becomes most effective when he sits down." Then, after motion pictures of Section activities, including the West Point Outing, the speaker of the evening was introduced by Chairman Wolf.

Historical Background Sketched

Beginning logically with the historical background for free-wheeling of today, Mr. Roos, giving due credit to his collaborator, W. S. James, went on to show pictures of the various mechanisms by which free-wheeling has been attained in the past and to explain the action of those devices. Among the many covered were the de-Lavaud rear-axle design, the Weller modified clutch, the Vulcan mechanism and the Farley applications to the transmission countershaft and main-shaft constant-mesh gears. Attention was directed to the Joseph design and the Humphrey-Sandberg design, in both of which the popular multiple roller cams are used. Other types of multiple roller-cam mechanism mentioned were the Toothill unidirectional drive unit, the Milam free wheel as applied to the Arrol Aster chassis, and the high-capacity Constantinesco automatic transmission. The Pitter lever clutch and the L. G. S. coil-spring clutch were also discussed.

In contrast to these, Mr. Roos presented the pineapple design as developed by Studebaker. Here the free-wheel unit consists of an inner cam member having three lobes, which is splined directly to the main shaft, an outer ring member, and three sets each of four rollers graduated in diameter to conform to the cam profile. The speaker carefully detailed the operation of each element of the free-wheel transmission.

Bugaboos Vanquished by Tests

Having established the background and enlarged upon the particular system used by his company, Mr. Roos proceeded to an analysis of the results obtained in a comprehensive series of tests. The first one mentioned was carried out on a chassis dynamometer to establish durability. With an automatic throttle-control continually accelerating the car in second gear from 20 up to 30 m.p.h. and then free-wheeling it back to 20 m.p.h., it was found that in the final design the unit would operate successfully with virtually no wear on the rolls, cam, or roll race for 50,000 cycles with only three rolls of any one size.

It was stated that the much-debated matter of increased brake usage was shown by exhaustive tests to be less of a bugaboo than is generally believed. "It has been found," said Mr. Roos, "that an increase in brake capacity of 20 per cent is more than ample to take care of free-wheel conditions." A series of tables was presented indicating that, in general, only 5 lb. more pedal pressure is needed to give the same deceleration to a free-wheeling car as to a conventionally geared car. The speaker also made it evident that he felt that the braking effectiveness of the engine is usually overvalued. "If the engine has been such an important member in braking a car," he said, "it would seem rather strange that in all the years of history of the development of the automobile, so little was done to further development of the engine's braking power."

Other factors touched upon in more or less detail included (*a*) the need for an increase in generator speed to compensate for a decrease in ampere-hour charge of 5 to 15 per cent caused by free-wheeling with the engine idle; (*b*) the disadvantage of lower average pump and fan speeds in summer, which is offset by the advantage of this condition in winter; (*c*) increase in engine life; (*d*) increase in clutch life, owing to less frequent use; (*e*) the benefit to transmission gears and bearings, to propeller shaft, to rear axle and to tires of the elimination of coast loads; and (*f*) the saving of fuel and oil.

Discussers Propound Pertinent Questions

Discussion which followed included the reading of letters from T. J. Litle, Jr., of the Holly Carburetor Co.; E. R. Fish, of the Brown-Lipe Gear Co.; Fred Duesenberg, and F. E. Watts, of Hupp Motors.

E. S. Marks, chief engineer of the Franklin Automobile Co., was present. He asked about the lapse of time which occurs between the instant the throttle is opened with the engine idle and the car free-wheeling and the point at which the engine begins to pull the car, about the necessity for higher engine-idling speeds to prevent stalling, and whether the intermittent periods of free-wheeling quiet do not attract attention to engine and car noises with power on. These conditions exist, said Mr. Roos, to the advantage of free-wheeling, because there is no jerk when the engine picks up the car, the free-wheeling transmission is quiet and easily shifted at slightly higher idle speed than conventional transmissions, and the contrast between free-wheeling and constant power helps sell the car.

Joseph A. Anglada told of his experience with roller clutches, pointing out that eventually grit in the lubricant acts as a lap beneath the rollers and cams and wears depressions in the contact surfaces, preventing operation. Mr. Roos countered with a statement on the life tests and later said that

the equivalent of 150,000 miles of service had been given in testing.

Doctor Carl W. Weiss inquired why the Constantinesco type of clutch was not used, to which Mr. Roos replied that the lack of space in the transmission case prevented it in any event and intimated that the pineapple design was believed less complicated and just as effective for the work to be done.

Others who discussed the paper were F. E. Moskovics, Carl Scott, Prof. A. E. Becker, Prof. F. H. Dutcher, M. C. Horine, F. K. Glynn, C. B. Veal, F. C. McManus, W. S. Peper, R. P. Breese, W. E. John and L. G. Nilson.

The meeting closed with the showing of motion pictures of the National Air Races that were held in Chicago last August.

For November, Metropolitan Section announces a meeting at the A. W. A. Clubhouse on Wednesday, the 19th, with the subject, What Engineering Has Done for the Garage. Milton A. Kent, president of the Kent Garage Companies, and his assistant, Sydney R. Dresser, will speak. The meeting will be preceded by dinner as usual and followed by an inspection of the Kent Garage at 61st Street, near Ninth Avenue, New York City.

Motor Fuels Considered

Philadelphia Section Hears Dr. Bridgeman on Relation of Gasoline to Engine Design

AT ITS October meeting the Philadelphia Section enjoyed a helpful and interesting talk on Gasoline by Dr. O. C. Bridgeman, of the Bureau of Standards. At the start Dr. Bridgeman hazarded a prediction that the oil refiner who was able to anticipate the popular and fashionable color for women's clothes and match this with the color of his gasoline would probably reap a large return in increased sales, at least from the feminine members of the driving fraternity. If his suggestion, coming as it does from an engineer, is able to successfully pass the eagle eyes of the sales departments, we may yet see gasoline advertisements carrying the information that the refiner has a personal representative in Paris to assure the exact tint which will best match milady's costume for the coming summer.

Must Compromise Ideal Characteristics

Going from the realm of conjecture to that of hard fact, or as near hard fact as our present engineering abilities permit, the characteristics of a gasoline which determine its performance in the engine were described. The essential properties that a gasoline must possess, said Dr. Bridgeman, are ability to give easy starting, rapid acceleration, good distribution, and low dilution of the crankcase oil, together with non-corrosiveness from the presence of sulphur, lack of tendency to vapor-lock, high antiknock value, and lack of gum-forming constituents. An ideal fuel would be one which fulfills these requirements completely, but some of the requirements are at variance with others, so the commercial product must represent a compromise.

The gasolines available today to motorists represent each refiner's attempt to balance the varying requirements of present-day automobile engines and an economic use of the stocks and crudes available. It can be seen, moreover, that no one specified gasoline can best meet the requirements of all cars. Variations in design necessitate differences in fuels to produce optimum performance with each. The oil refiner and the automobile engineer are working more closely together today than ever before to so modify fuels and engine design that a more generally satisfactory matching of car and fuel will result.

How Engine Designer Can Help

When the car designer will so lay out his fuel system that gasoline temperatures of 200 deg. fahr., as have been observed at times, are impossible, the problems of the refiner will be reduced and the satisfaction of the car owner increased. No reason exists why fuel systems cannot be so designed that the maximum temperature of the gasoline in the system will not rise more than 30 deg. above the temperature of the atmosphere. With all cars meeting this condition, the conflict between ease of starting and vapor lock will be minimized, according to Dr. Bridgeman.

Improvements are also possible to a lesser degree in manifold design and its relation to distribution of the fuel mixture. A parallel case is in a general improvement of the combustion-chamber design so that higher compression-ratios can be employed without necessitating gasolines of abnormally high antiknock value. There are at present in the market cars of high compression-ratio which do not require fuel of as high an antiknock value as do other cars of lower compression-ratios, indicating the importance of combustion-chamber design.

Refiner's Difficulties Described

Needless to say, Dr. Bridgeman's talk called forth a great deal of discussion. An interesting point brought up was that during the spring and autumn the fuel refiner is in much the same predicament as the farmer in his rôle as weather forecaster. In an endeavor to give ease of starting in cold weather and to prevent vapor-lock difficulties in warm weather, nearly all refiners bring out a winter and a summer grade of gasoline. In selecting a time to change this product in the spring and autumn, he is simply endeavoring to out-guess the weather. If a hot spell occurs in the early spring before he has made his change, he is deluged with complaints of vapor lock, while, if a cold spell is experienced after he has made the change to a summer grade, complaints of starting difficulty are received. A similar situation exists in the autumn.

The question was also brought up as to how the car owner or the service manager could best select the gasoline which would prove most satisfactory in an individual car. To this there seemed no answer except that of trial. While such tests must necessarily be somewhat crude, the car owner can, and in most cases does, select a fuel that seems to him to be satisfactory. He may not obtain the optimum of performance with the present diversity of design and requirement of modern engines, but this is the only ready means available to him.

Vapor Lock and Fuel Systems

In the discussion on vapor lock, it was pointed out that in many respects systems employing a fuel pump are more susceptible to this phenomenon than the old vacuum-tank system. In the latter system, the vacuum tank functions to distill off a portion of the lighter ends of the fuel and to that extent tends to prevent vapor lock. However, this blessing is accompanied by the curse of lowered volatility for starting, for the engine must be started with the gasoline remaining in the vacuum tank and carbureter, and, if much of the light ends has been removed, starting is that much more difficult.

In aircraft work there have probably been many cases in which dirt in the fuel lines was assumed to be the cause of crashes which have actually been due to vapor lock. Virtually any fuel system will be found to contain some dirt, and, in lieu of some other explanation, this has been seized upon as the probable cause of engine failures. Water in the gasoline has also been blamed for similar failures. In the preparation of aviation and automobile fuels, every precaution is taken by the reputable refiner to preclude the possibility of water being present in the gasoline when shipped. Water at times does, however, collect in the

gasoline tank of an automobile, as the result of condensation of water vapor inside the tank with changing air-temperatures.

Diesel-Engine Advantages Told at Washington

ADVANTAGES of Diesel engines in comparison with gasoline engines were discussed by H. C. Edwards, chief engineer of the aeronautical engine division of the Packard Motor Co., at the Oct. 7 meeting of the Washington Section at the Washington Hotel. Seventy members and guests were present, fifty-seven of whom enjoyed a well-served dinner, from oysters on the half-shell to Jersey-cow ice cream. Among those present were C. B. Veal, research manager of the Society; Louis Chevrolet, of Chevrolet Motors, Inc., and Mrs. Chevrolet; L. C. Milburn, chief engineer of the Glenn L. Martin Co., and Mrs. Milburn; G. O. Pooley, A. B. Boehm and V. P. Williams, three officers of the Baltimore Section.

Edwards Explains Packard Engine

In speaking of the Packard Diesel engine, Mr. Edwards said that he felt he was venturing on ground sacred to Capt. L. M. Woolson, who worked patiently to bring the engine to its present state of perfection only to meet an untimely death. Reliability and safety are principal considerations in the development of any engine, said Mr. Edwards, and no effort had been spared to give these to the Packard Diesel. As crashes usually end in fire, safety from the fire hazard of the gasoline engines is one of the chief advantages of the Diesel engine.

Better fuel economy but abnormal cylinder pressures characterize a Diesel as compared with a gasoline engine. While the power of the Diesel should be greater for the same piston displacement, it is not in the present engines, partly because of safety factors allowed.

Individual fuel-pumps on the cylinders, with low-pressure distribution lines, were adopted as more desirable than having all the fuel lines carrying the high injection-pressures. Pieces of rubber hose were inserted in the fuel lines to damp out vibrations.

Starting is by means of an ordinary electric inertia-starter, and, while the engine is immediately ready to develop full power, time must be allowed for the lubricating oil to circulate and warm up. The danger of accidental starting when working on a hot engine is eliminated.

Altitude control is not essential on a Diesel engine, which operates with a surplus of air and still has enough to develop its power at considerable altitudes. With unsupercharged engines, at 20,000-ft. altitude, a 350-hp. gasoline engine would be necessary to equal the power output of a 225-hp. Diesel.

A single valve per cylinder, with twelve springs per valve, are other features mentioned by the speaker. The large number of springs was adopted as a safety factor, the small-sized piano wire being easier to obtain in good quality, and, even with two or three springs broken, the operation of a cylinder would not be affected.

Two reels of movies of the National Air Races in Chicago last August were shown, and these were supplemented by Lieut.-Commander E. W. Rounds, who was a timer at the races. A reel was also shown of Colonel Lindbergh's transatlantic flight and of the crashes which occurred in previous attempts to make the flight.

Miss Blanche Arison and the Maycliff Sisters gave a fitting climax of piano music, songs and dancing to an otherwise profitable evening.

Headlighting Situation Demonstrated for Buffalo Section

ONE of the most interesting sessions held by the Buffalo Section was that of Oct. 14, at which W. M. Johnson, commercial engineer of the National Lamp Works of the General Electric Co., at Cleveland, not only drew a word picture of the part that good headlighting plays in safe night driving, but gave a demonstration of the lighting effects produced by the latest type of electric head-lamps.

The meeting was held at the Hotel Statler and was attended by 60 members and guests, many of whom took part in the lively discussion following Mr. Johnson's address, which was the same that he gave at the October meeting of the New England Section, in the report of which in this issue of THE JOURNAL a short synopsis of the address is given. The subject was excellently handled, and numerous appreciative comments upon it were made. Among those who took part in the discussion were A. F. Carlson, of the Pierce-Arrow Motor Car Co.; E. A. Oehler, of the Stewart Motor Corp.; L. P. Saunders, of the Harrison Radiator Corp.; Gustaf Carvelli, of the Curtiss Aeroplane & Motor Co.; and W. E. England.

Points Debated in Discussion

Several speakers commented on the desirability of using slightly colored lenses for night driving, which some believe is distinctly advantageous. One discusser made a strong plea for the substitution of green for red in tail-lamps, reserving red for the stop-light only. There followed a long discussion on the use of red in tail-lamps and the relative visibility of various colors at night.

Another point debated was the vertical displacement of the beam by the loading of heavy trucks and the best compromise angle of the beam to take care of the variation of rear-spring deflection between the empty and loaded condition of motor-vehicles.

Influences on the head-lighting of height of the lamps above the road surface, of the greater lateral distance between the head-lamps on the fenders of the Pierce-Arrow cars, and of eliminating a part of the direct beam of the head-lamps were other points discussed.

There was also considerable debate regarding the relative advantage of deflecting the beams to the right side, or to the side and down, rather than down only.

Free-Wheeling Discussed by Dayton Section

THE October meeting of the Dayton Section was held on the night of the 22nd and began with a dinner, at which a score were present. Among the guests was W. S. James, of the Studebaker Corp., who was the speaker at the technical session. Officers and members of the Section also sat at the tables, and Carl Kindl, Chairman, presided over both the dinner and the technical session.

Eighty members and guests listened to the presentation by Mr. James of a paper on Free-Wheeling, which was illustrated with lantern slides. This was the same paper that was given by Delmar G. Roos at the meeting of the Metropolitan Section meeting in New York City on Oct. 16, as reported in this issue of the S.A.E. JOURNAL. A local dealer provided a Studebaker free-wheeling car for demonstration purposes.

The paper was very well received, the effect of free-wheeling on the general operation and handling of the car as compared with the conventional transmission proving particularly interesting to all present. The meeting was highly successful.

Wind-Tunnel Session at Wichita

THE FIRST fall meeting of the Wichita Section opened with a bang on Oct. 9, under the able direction of Al Mooney, the new Chairman who has succeeded Mac Short. Al evidently realizes his responsibility to uphold the good reputation of his predecessor, for his first bright move was to establish the fact that the Section dinners would be held at a new stand. About 25 members gathered under the roof of the famous Green Parrot Inn for a home-style dinner. Assuming the truth of the celebrated saying that "an army moves on its stomach," the local gang ought to go far this year.

(*Concluded on p.* 627)

Man Captured!

The Man Who Was Sought Is Found, But Other Men Are Now Wanted

WE'RE sorry, folks, but the man-hunt made public in the columns of the S.A.E. JOURNAL last month is over and the reward has been collected—in part. The remaining installments will be paid in due course; in fact, the payments will stretch over an unusually long time. Amazing as it may seem, the one who is paying the reward won't mind how long it will take him to rid himself of debt, because the "payer" and the "payee" are alike responsible and will profit mutually. This may sound like bad financing, and show deplorable leniency on the part of the creditor; but let us explain, in case you didn't read our article last month in the S.A.E. JOURNAL.

The man for whom the reward was offered was a person of many talents; he had a flair for originality, combined with a practical sense and backed by a sound education. His sincerely genial manner made him liked by all and secured him a high degree of cooperation, which was a decided help in the solution of business problems and the acquisition of new ideas. In short, this man who was being sought was a person of real breadth of view and depth of interest, and when he was found (how, we'll tell you later in the story) his capabilities proved of incalculable value to the finder, an executive who held a responsible position in a well-known organization and who was seeking a man to fill a job that "looked toward higher things."

As for the reward at stake, the executive will be repaid by the unflagging efforts of the young man to do efficiently whatever task he may be assigned; the young man will be rewarded in the ultimate recognition of his worth. He will be assigned to more responsible jobs as time goes on and as he shows himself worthy of trust; these assignments will result in a measurable increase in salary and an immeasurable increase in business prestige. Thus the "man-hunter" and the "man hunted" share equally in the reward—an intangible thing in itself but productive of very substantial material gains.

The Hunt Is Continued

As we have said, the man-hunt instigated last month is over, but we have good news for the inveterate thrill seekers. A bigger and better man-hunt is on. This all came about as a result of our call for help which appeared in THE JOURNAL last month, and we must confess that we are in a quandary as to how we shall deal with the situation that has arisen. Our enthusiasm over the man-hunt seems to have been infectious, and the infection is spreading so fast that we are unable to cope with it single-handed. So we have asked our cohorts, the Sections of the Society, to help us out.

The new man-hunt that is on involves many men who are being sought and many people who are doing the seeking. Write now to S.A.E. Headquarters, 29 West 39th Street, New York City, or to your local Section Secretary for the details. Better yet, pay a personal call. Join the man-hunt, and help us to effect an agreement between the engineer seeking a job and the employer seeking an engineer.

But we haven't told you yet how our first man was found. It was through the S.A.E. Employment Service, available to all members of the Society without charge. This service enables companies to locate just the man they need for a vacancy, and it provides an opportunity for a man seeking a new job or a better job to secure one that is commensurate with his qualifications.

Heretofore, this service was conducted exclusively at S.A.E. Headquarters, 29 West 39th Street, New York City, and at the Detroit office, 2-136 General Motors Building. Due to the increasing need for a wider scope of this branch of the Society's work, the local Sections are to cooperate in the effort to bring together the men seeking jobs and the companies seeking men. The practice of sending the semi-weekly bulletins, issued by the Employment Service and listing Men Available and Positions Available, to those requesting them will be continued, but in addition there will now be an opportunity for an individual or company to contact directly with the Section Secretary nearest him with regard to employment matters, where he may expect and will receive the closest attention to his particular problem.

When you are contemplating employing engineers, let the S.A.E. office know about it, and we will do our best to help you establish contacts with just the type of men you want. If you are a member of the Society and wish to make a new connection, let the S.A.E. know and we will try to suit your needs exactly. Most important of all, don't forget that this service to employers and prospective employes is WITHOUT CHARGE.

If you would like to have your name put on the mailing list to receive the semi-weekly bulletins of either Men Available or Positions Available, let us know and we will gladly comply with your request.

Join the ranks of the man-hunters and reap your just reward!

S.A.E. Section Secretaries for 1930-1931

Baltimore—Joseph Bavett, superintendent of machinery, Yellow Cab Co., 508 East Preston Street, Baltimore

Buffalo—A. F. Carlson, chief draftsman, Pierce-Arrow Motor Car Co., Buffalo

Canadian—Warren Hastings, editor and manager, *Canadian Motorist*, Lumsden Building, Toronto, Canada

Chicago—O. R. Schoenrock, director of engineering, Oliver Farm Equipment Co., 400 West Madison Street, Chicago

Cleveland—Hoy Stevens, assistant superintendent of maintenance, motorcoach department, Cleveland Railways Co., 1809 St. Clair Avenue, Cleveland

Dayton—G. W. Frank, mechanical engineer, Material Division, United States Army, Air Corps, Wright Field, Dayton, Ohio

Detroit—D. E. Anderson. Assistant Secretary, B. Brede, 2-136 General Motors Building, Detroit

Indiana—Harlow Hyde, executive secretary, Indianapolis Automobile Trade Assn., 338 North Delaware Street, Indianapolis

Metropolitan—Grosvenor Hotchkiss, care S.A.E., 29 West 39th Street, New York City

Milwaukee—Prescott C. Ritchie, advertising manager, Waukesha Motor Co., Waukesha

New England—H. B. Hawk, resident manager, Valvoline Oil Co., 175 Cottage Street, Chelsea, Mass.

Northwest—C. H. Bolin, general motor-vehicle supervisor, Pacific Telephone & Telegraph Co., 433 Dexter Horton Building, Seattle

Northern California—W. S. Crowell, claims adjuster, Home Accident Insurance Co., 1462 Waller Street, San Francisco

Oregon—F. P. Myers, president and manager, Myers-Blackwell Co., 55 Union Avenue, Portland

Philadelphia—J. P. Stewart, automotive research engineer, P. O. Box 159, Woodbury Heights, N. J.

Pittsburgh—C. R. Noll, automotive lubrication engineer, Gulf Refining Co., 1157 Frick Building Annex, Pittsburgh

Southern California—C. H. Jacobsen, service manager, Moreland Motor Truck Co., Los Angeles

St. Louis—John Cox, automotive engineer, hydraulic brake division, Wagner Electric Corp., 6400 Plymouth Avenue, St. Louis

Syracuse—L. W. Moulton, partner, Manufacturers' Consulting Engineers, 507 McCarthy Building, Syracuse

Washington—John C. McCalmont, assistant aeronautic engineer, Bureau of Aeronautics, Navy Department, Washington, D. C.

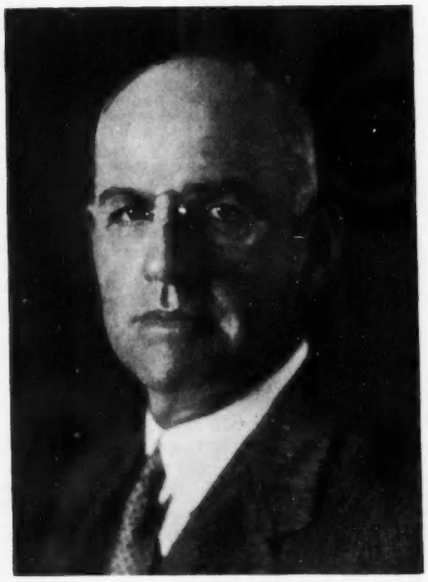
Wichita—W. W. McCutcheon, Stearman Aircraft Co., Wichita, Kan.

Personal Notes of the Members

Macauley Urges Sound Highway Financing

A plea for the sound financing of highways was made in an address to the 650 delegates at the Sixth International Road Congress in the City of Washington on Oct. 7 by Alvan Macauley, president of the National Automobile Chamber of Commerce, president and general manager of the Packard Motor Car Co., and an Affiliate Representative in the Society since 1915.

"The chief obstacle to good roads," said Mr. Macauley, "is financing; if this is other than sound it will not attract the investors' money. There is



ALVAN MACAULEY

still no entire and complete agreement as to the best way of financing highways, but fortunately opinion is crystallizing as to the general principles involved."

A general agreement among the delegates as to the essentials of sound financing would go far to settle the question for all time, in Mr. Macauley's opinion. The automobile requires only good roads to make the world's resources available to man, and more and more it is becoming apparent, he said, that the wealth of a nation is in direct proportion to the use made of its natural resources.

Objection was made by Lucien Lipman, chief engineer of roads and bridges in Paris, to the principle enunciated in a report by A. B. Barber, director of the National Conference on Street and Highway Safety, that revenues received from automobile licenses and taxes, including gasoline taxes, should be expended solely on highway work. The French delegate expressed the conviction that his government would not want to deprive the treasury of all resources derived from use of the highways. Colonel Barber opposed any change in the statement of the principle, however, and was supported by Sir Seymour Williams, of the British Ministry of Transport; Dr. Weiner Feilchenfeld, of the German delegation; Carl O. Fritsch, vice-president of the German Automobile Club; and E. J. Mehren, of the McGraw-Hill Co., and when a motion to adopt that section of the report was made, no opposition vote was audible.

The session also went on record as approving the granting of loans or subsidies by national governments to the component parts of that government, the providing of systematic maintenance of roads that have been completed and regarding such maintenance as a first charge upon the user revenues in the case of improved highways of general use, and the use of general tax revenues and bond issues for highway purposes.

Those who attended the Summer meeting at French Lick last May will recall that Mr. Macauley made a brief address by telephone from his home in Detroit to members of the Society assembled at the 25th Anniversary Session. In that address, which was amplified by the loud-speakers of the public-address system, Mr. Macauley congratulated the Society upon its accomplishments and predicted greater accomplishments to come.

Birdsall Joins Lawrance Corporation

Edward T. Birdsall, former engineer in the engineering and research department of the Curtiss-Wright Corp., of New York City, has announced his resignation from that company and his appointment as chief engineer of the Lawrance Engineering & Research Corp., also of New York City.

Mr. Birdsall is one of half a dozen men whose names are most closely linked with the organization of the Society a quarter of a century ago, as he was instrumental in bringing about the meeting that resulted in the formation of the Society in 1904. He was elected its first Secretary and Treasurer. His work in the ranks of the Society, especially on committees, has won for him the regard and high esteem of all with whom he has come in contact.

An interesting address, delivered by Mr. Birdsall at the 25th Anniversary Meeting at French Lick, Ind., and printed in the June, 1930, issue of the S.A.E. JOURNAL, p. 662, gives a vivid picture of the obstacles overcome and the prejudices removed when the nine men who founded the Society started to make it a live, growing organization.

Mr. Birdsall has been identified with the automotive industry from its inception in this Country as a designer, builder and consulting engineer. He is a graduate of the Stevens Institute of Technology in Hoboken, N. J. In 1928 he severed an eight-year connection with the Parker Rust Proof Co., of Cleveland, as president and treasurer and sold his interest in the company. Concurrently he served the Butler Mfg. Co., also of Cleveland, in the capacity of director in charge of engineering, and more recently the Wright Aeronautical Corp. and the Curtiss-Wright Corp. as research engineer.

Watson Elected Steel Treaters' President

J. M. Watson, long-time Member of the Society and well known as Chairman of the Iron and Steel Division of the Standards Committee since 1925, has been accorded the signal honor of being the first man in the automobile industry to be elected president of the American Society for Steel Treating.

J. M. WATSON

Mr. Watson is chief metallurgist of the Hupp Motor Car Co., which he has served for a number of years, first in

(*Continued on p.* 40)

Applicants Qualified

The following applicants have qualified for admission to the Society between Sept. 10 and Oct. 10, 1930. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALLEN, CHARLES W. (J) motor tester, Packard Motor Car Co., 2068 East Grand Boulevard, *Detroit.*

BABCOCK, IRVING B. (A) executive vice-president, General Motors Truck Corp., South Boulevard, *Pontiac, Mich.*

BALLIN, ALFRED EDWARD (M) president, general manager, McIntosh & Seymour Corp., *Auburn, N. Y.;* (mail) 100 South Street.

BEHRNDT, FRANKLIN J. (J) tool designer and draftsman, Fokker Aircraft Corp. of America, *Hackensack, N. J.;* (mail) Room 314, Y.M.C.A.

BICKELL, J. P. (A) registrar of motor vehicles, Motor Vehicles Branch, Department of Public Highways, Parliament Buildings, *Toronto, Ont., Canada.*

BRINER, EMIL AMANDUS (M) consulting mechanical engineer, 164 South Clinton Street, *East Orange, N. J.*

BUTLER, OTIS W. (A) owner, service and consultant service, 1253 South Hoover Street, *Los Angeles.*

CHRISTENSON, HELMER GERHART (A) branch manager, National Battery Co.; district manager, Gould Storage Battery Corp., 6534 Benson Street, *Detroit;* (mail) National Battery Co.

COX, H. L. (A) in charge of draftsmen, Canners Machinery, Ltd., *Simcoe, Ont., Canada;* (mail) Box 746.

DUBOIS, EDWARD P. (J) laboratory assistant, aeronautic department, University of Detroit, *Detroit;* (mail) 7703 Sherwood Avenue.

EDLING, J. J. HENRY (M) body-die designing engineer, checker, Fisher Body Corp., Plant 23, Division of General Motors Corp., *Detroit;* (mail) 66 West Margaret.

FERNLY, J. E. (A) foreman, shop and test departments, Packard, Inc., *Philadelphia;* (mail) 7728 Michener Street.

GALLOWAY, ROBERT B. (M) production engineer, Aeronautical Corp. of America, *Cincinnati;* (mail) 3600 Petoskey Avenue, Mariemont.

GETZOFF, EDWARD M. (M) mechanical engineer, supervision of gasoline-engines testing, International Motor Co., Testing Labortory, Plainfield, N. J.; (mail) 1045 North Avenue, *Elizabeth, N. J.*

GOLDMANN, DAVID H. (A) president, K. & G. Sales Co., *Baltimore;* (mail) 3911 Barrington Road.

GUEST, JOHN ADOLPHUS (A) marine superintendent, inspector of launches, H. M. Customs, *Rangoon, Burma, India.*

HAARTZ, JOHN CARL (A) president, treasurer, Haartz Auto Fabric Co., Cambridge, Mass.; (mail) 33 Wedgemere Avenue, *Winchester, Mass.*

HAVER, FRED J. (M) technical service engineer, American LaFrance & Foamite Corp., *Elmira, N. Y.;* (mail) 405 West Gray Street.

HEGGEN, EDGAR ALEXANDER (A) garage superintendent, Carnation Farm Products Co., Inc., *Seattle, Wash.;* (mail) 5409 First Avenue, Northeast.

HOGEMANN, HANS (J) engineering draftsman, Elco Works, *Bayonne, N. J.*

IRON CITY SPRING CO., INC. (Aff.) 2916-2920 Smallman Street, *Pittsburgh, Pa.;* Representatives; Austen, Robert N., sales manager, engineer; Taylor, W. D., president, general manager.

JESTER, MAXWELL B. (M) chief chemist, lubricating engineer, Calumet Refining Co., 4323 South Western Boulevard, *Chicago.*

KAUFMAN, EMORY B. (A) member of firm, general manager, K. & G. Sales Co., *Baltimore;* (mail) 2432 Barclay Street.

KOCHMAN, SAMUEL A. (J) chief draftsman, Accurate Parts Mfg. Co., 735 Central Avenue, *Cleveland.*

KOLLSMAN, PAUL (M) owner, manager, Kollsman Instrument Co., 47 Dinsmore Place, *Brooklyn, N. Y.*

LAMB, WARD E. (J) truck and bus layout, retail design, C. H. Will Motors Corp., *Minneapolis;* (mail) 3500 First Avenue, South.

LANZ, WALTER JOHN (J) 25 New Hampshire Street, *Long Beach, N. Y.*

LEVY, DUDLEY D. (J) president, engineer, Dudley Engineering Corp., 151-153 West 28th Street, *New York City.*

LEWIS, EDWARD H. (M) designing engineer, General Electric Co., *Bridgeport, Conn.*

MCNALLY, JOHN D. (A) salesman, White Co., *Pittsburgh;* (mail) 458 Melwood Street.

MERSHON, LESTER ODELL (A) shop foreman, Hancock Auto Repair, *Seattle, Wash.;* (mail) 1011 East 73rd Street.

MORAN, F. S. (A) service manager, General Motors Japan, Ltd., *Osaka, Japan;* (mail) P. O. Box 151.

PETERSON, WALTER THOMAS (A) manager of sales, Detroit office, Pennsylvania Rivet Corp., Philadelphia; (mail) Room 248, 4464 Cass Avenue, *Detroit.*

PHELPS, EMORY FRANCIS (M) superintendent of maintenance, Blue Club Coach Lines, Inc., *Bridgeport, Conn.;* (mail) 50 Bennett Street.

PRESTON, JOHN H. (A) field representative, truck department, Chevrolet Motor Co., 1881 Broadway, *New York City.*

RZEPPA, ALFRED H. (M) consulting engineer, experimental work, Gear Grinding Machine Co., *Detroit;* (mail) 1023 Kensington Road, Grosse Pointe Park.

SCHNEIDER, RUDOLPH (M) chief designing engineer, Busch-Sulzer Bros. Diesel Engine Co., Second and Utah Streets, *St. Louis.*

SCOTT, CHARLES EZBAI (A) sales engineer, in charge of aircraft division, Haskelite Mfg. Corp., Room 1120, 120 South LaSalle Street, *Chicago.*

SOCIETE ANONYME DES ACIERIES, GEORGES FISCHER (Aff.) *Schaffhouse, Switzerland;* Representative: Buss, J. F., engineer.

SPEARMAN, GEORGE H. (J) instructor of industrial education, San Jose State College, *San Jose, Calif.*

STAHL, E. J. (A) executive vice-president, in charge of body division, Baker-Raulang Co., Cleveland; (mail) 12527 Clifton Boulevard, *Lakewood, Ohio.*

STEARNS, RAYMOND W. (A) sales manager, Culver-Stearns Mfg. Co., 3-153 General Motors Building, *Detroit.*

SWANSON, HARRY J. (M) president, treasurer, in charge of sales and engineering, Ottawa Steel Products, Inc., 841 Woodlawn Avenue, *Grand Haven, Mich.*

TAYLOR, EDWARD NELSON (M) president's assistant, Bart Reflector Co., Newark, N. J.; (mail) 7 Patton Place, *Upper Montclair, N. J.*

TAYLOR, PERCIVAL JOHN (F M) proprietor, chief engineer, P. J. Taylor & Co., Liverpool and Riley Streets, *Sydney, New South Wales, Australia.*

THOMPSON, WILLIAM M. (A) chief, mechanics school, Parks Air College, *East St. Louis, Mo.*

THYSSE, JOHN (M) assistant engineer, Hercules Motors Corp., *Canton, Ohio;* (mail) 1400 North Market Street.

TREFZ, WALTER (M) Climax-Jones & Quinn, *St. Louis;* (mail) 4958 Lilburn Avenue.

TYLER, WALTER L. (A) sales engineer, Willard Storage Battery Co., Box 1358, Arcade Station, *Los Angeles.*

UNITED REFINING CO. (Aff.) *Warren, Pa.;* Representative: Houston, MacLean, production manager.

URY, MATTHEW (A) president, General Auto Electric Co., 239 East 149th Street, *New York City.*

VAIL, PHILIP S. (M) general superintendent of transportation, Langendorf United Bakeries, Inc., *San Francisco;* (mail) 1230 Golden Gate Avenue.

VAIL, RICHARD (M) editor, Autobody Publishing Co., Inc., 1819 Broadway, *New York City.*

VIEIRA-RIBEIRO, ALBERTO A. (J) service manager, Wallace Harper & Co., Ltd., Kowloon, *Hong-Kong, China;* (mail) 12 Salisbury Avenue.

WALKER, AVERY W. (A) superintendent, sander department, Carborundum Co., *Niagara Falls, N. Y.;* (mail) 551 11th Street.

WALKER, GEORGE SUTHERLAND (A) president, Sunset Tire Corp., Eighth and Burnside Streets, *Portland, Ore.*

WEATHERHEAD CO. (Aff.) 632-714 Frankfort Avenue, *Cleveland;* Representative: Stecher, H. D., engineer.

WHEELER, GEORGE F. (M) chief, industrial investigations division, Black & Bigelow, Inc., New York Cty; (mail) *Riverside, Conn.*

WHIPPLE, OLIVER B. (A) service and parts manager, Sturgeon & Beck, *Tulare, Calif.;* (mail) P. O. Box 783.

WHITE, EBER B. (M) foreman, experimental engineering, Studebaker Corp. of America, *South Bend, Ind.;* (mail) 902 Blaine Avenue.

WILLIAMS, DUNCAN B. (J) engineer, automotive division, Carbide & Carbon Chemicals Corp., 30 East 42nd Street, *New York City.*

WILLIAMS, GEORGE L. (J) student, Massachusetts Institute of Technology, Cambridge, Mass.; (mail) 35 Audubon Road, *Boston.*

WILLIAMS, RICHARD JAMISON (J) assistant department head, products development, Budd Wheel Co., *Detroit;* (mail) 131 Gladstone Avenue.

WILLIAMS, SYDNEY NORMAN (A) British Service Proprietary, Ltd., 197-209 Sturt Street, *South Melbourne, S. C. 4, Australia.*

WILLIAMS, W. F. (A) mechanical salesman, Standard Oil Co. of California, Oakland, Cal.; (mail) RFD Number 1, Box 377, *Walnut Creek, Calif.*

WINHALL, ERIC HERBERT (J) chief draftsman, designer, Automotive Engineering Co., Ltd., 104, The Green, *Twickenham, England.*

WISHEU, JOSEPH (A) service department manager, Sullivan Morgan Motor Sales Co., *Chicago;* (mail) 4631 Armitage Avenue.

WORTMAN, O. W. (A) vice-president, Aircraft Steel Co., 210 South Wichita Street, *Wichita, Kan.*

WURTZ, ALBERT L. (M) general motor-vehicle supervision, engineering work, Bell Telephone Co. of Pennsylvania, 416 Seventh Avenue, *Pittsburgh.*

YASHIRO, FUSAO (F M) commercial engineer, Shibaura Engineering Works, Shiba, Kanasugi, *Tokyo, Japan.*

ZONGKER, C. E. (A) 111 North Gillette Avenue, *Tulsa, Okla.*

Applicants for Membership

The applications for membership received between Sept. 15 and Oct. 15, 1930, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALLEN, R. H., manager at Cedar Rapids, Allen Motor Co., *Cedar Rapids, Iowa.*

ALMSTEAD, CHARLES W., European representative, Warner Electric Brake Corp., *Dallas, Texas.*

ARMER, JAMES C., vice-president in charge of sales, Dominion Forge & Stamping Co., Ltd., *Walkerville, Ont., Canada;* and Canadian Motor Lamp Co., Ltd., *East Winsor, Ont., Canada.*

ASTRUP, WILLIAM V., chief draftsman, Young Radiator Co., *Racine, Wis.*

AUSTEN, EMERSON A., field service engineer, Pioneer Instrument Co., *Brooklyn, N. Y.*

AUSTIN, CALVIN TULLER, engineer, 3617 Sierra Vista Ave., *Glendale, Calif.*

BAKKE, E. K., president, Bakke-Daniels, Inc., *Vancouver, Wash.*

BAYLEY, G. ROLAND, draftsman, Buick Motor Co., *Flint, Mich.*

BLACK, HARRY DAVIS, junior engineer, The Buda Co., *Harvey, Ill.*

BRADER, JOHN HARRY, assistant chief engineer, Jacob Press Sons, *Chicago.*

BRADLEY, ARTHUR L., body draftsman, Ford Motor Co., *Dearborn, Mich.*

BROWNING, KENDALL COLIN, professor of chemistry and metallurgy, Military College of Science, *Woolwich, London, England.*

BROWNING, W. C., owner, Browning Garage, *Everett, Wash.*

BUCKLES, THOMAS A., manager and owner, Toms Super Service, *Portland, Ore.*

BUCKMEYER, CHARLES EDWARD, district manager, Raybestos Manhattan, Inc., *Bridgeport, Conn.*

BUNCH, CLARE WESLEY, branch manager, Pioneer Instrument Co., Inc., *Brooklyn, N. Y.*

CHENAULT, ROY L., engineer, Gulf Production & Pipe Line Co., *Pittsburgh.*

COMER, MELVIN ROSS, salesman and transportation surveyor, General Motors Truck Co., *Newark, N. J.*

CONNER, CLARENCE W., full-size body layout, Pierce-Arrow Motor Car Co., *Buffalo.*

DALTON, RICHARD, inspector, Wright Aeronautical Corp., *Paterson, N. J.*

DELANEY, GEORGE B., service representative, General Motors Truck Co., *Pontiac, Mich.*

FARMER, WALTER T., draftsman, Baldwin Locomotive Works, *Eddystone, Pa.*

FERRIS, LEROY, assistant secretary, Industrial Alcohol Institute, Inc., *New York City.*

FORD, WATSON I., field engineering department, tire development division, United States Rubber Co., *Detroit.*

GEIPEL, MARTIN A., drafting, Smith Engineering Co., *Cleveland.*

GEDDES, HOMER R., service department sales, A. Schrader's Son, Inc., *Toronto, Ont., Canada.*

GORDEN, WALTER L., experimental engineer, Johnson Motor Co., *Waukegan, Ill.*

GRASHORN, KARL GERHARD, experimental mechanic, Checker Cab Mfg. Corp., *Kalamazoo, Mich.*

HALL, ROBERT C., engineer, bus transportation, United Railways & Electric Co., *Baltimore.*

HANSEN, CLAUDE S., sales engineer, Fuller & Johnson Mfg. Co., *Madison, Wis.*

HASLAM, R. T., vice-president and general manager, Standard Oil Development Co., *New York City.*

JACKSON, FREDERICK P., engineer, resale carbureters, Bendix Stromberg Carburetor Co., *South Bend, Ind.*

JOHNSON, HAROLD A., JR., student, University of California, *Berkeley, Calif.*

JOHNSTON, LEIGHTON W., examiner, United States Patent Office, *City of Washington.*

KAESS, LOUIS LEDYARD, president, Kaess Aircraft Engineering Corp., *Amityville, N. Y.*

KIMBALL, W. S., president, Pittsburgh Auto Spring Co., *Pittsburgh.*

KOERNER, THEODORE W., mechanical assistant to president, Gemmer Mfg. Co., *Detroit.*

KOWALIK, LON, body records, Cadillac Motor Car Co., *Detroit.*

KUEHN, HENRY C., manager, treasurer, Kuehn's Automotive Co., *Portland, Ore.*

KUPEL, JOHN M., general superintendent, Little Giant Product, Inc., *Peoria, Ill.*

KURETH, DARWIN R., tool and die maker, Stout All Metal Airplane Co., Division of Ford Motor Co., *Detroit.*

LINDSEY, RICHARD H., chief engineer, Progressive Motor Devices, Inc., *Chicago.*

LITTLE, LESLIE FRANCIS, chief draftsman, Vickers-Armstrong, Ltd., *Chertsey, Surrey, England.*

LORENZEN, COBY, JR., junior aeronautical engineer, National Advisory Committee for Aeronautics, *Langley Field, Va.*

MALLETT, LLOYD ALFRED, assistant to chief engineer, Kenworth Motor Truck Corp., *Seattle, Wash.*

MARTIN, FRANK H., general salesman, assigned to lubrication, Standard Oil Co. of California, *San Diego, Calif.*

MERRITT, HENRY EDWARD, research engineer, David Brown & Sons, *Huddersfield, England.*

METCALFE, JOSEPH ARTHUR, tool engineer, A. S. Campbell Co., *East Boston, Mass.*

MILLER, CHARLES R., pilot sales manager, Mount Vernon Airways, Inc., *Alexandria, Va.*

MILLER, HARRY EMANUEL, 26 Van Ness Place, *Newark, N. J.*

MULERT, JUSTUS LOUIS, engineer, Gulf Production & Pipe Line Co., *Pittsburgh.*

NEUMANN, FERDINAND, die designer, Fisher Body Corp., *Detroit.*

RIVARD, LAWRENCE B., body engineer, Ford Motor Co., *Detroit.*

ROBINSON, HAROLD JEAN, superintendent of body construction, Loncoln Motor Co., *Detroit.*

ROEMING, WALTER FREDERICK, layout man, Wisconsin Motor Co., *Milwaukee.*

SCHULTZ, WOLDEMAR G., experimental engineering, body-layout draftsman in charge, Fisher Body Corp., *Detroit.*

SMITH, BRUCE, assistant chief draftsman, Travel Air Co., *Wichita, Kan.*

SOKOLOVSKY, SERGEI, assistant to process engineer, Fokker Aircraft Co. of America, *New York City.*

TAIT, T. E., manager, Australian Metal Equipment Co., *South Melbourne, Australia.*

TESTONI, FELICE ARMANDO, general manager, Societa Anonima Lepto, *Varese, Italy.*

TILEY, THOMAS C., supervisor, proving grounds division, Harrison Radiator Corp., *Lockport, N. Y.*

TOMPKINS, ROY, superintendent, Reliance Machine & Motor Co., *Brandon, Manitoba, Canada.*

UGER, DAVID A., mechanical engineer, chief aviation inspector, Amtorg Trading Corp., *New York City.*

UHLHORN, WILLIAM, general foreman, Leeds & Northrup Co., *Philadelphia.*

WALTON, D. E., manager commercial sales, American Oil Co., *Baltimore.*

WATARI, KATSUMI, inspector, Japanese Naval Inspectors Office, *New York City.*

WELCH, ALLEN T., garage foreman and plant engineer, Davidson Baking Co., *Portland, Ore.*

WIGHT, ARTHUR L., physical metallurgist, Linde Air Products Co., *Buffalo.*

WITHROW, FLOYD G., owner, Universal Spring Co., *Grand Rapids, Mich.*

WOOD, KARL D., assistant professor, Cornell University, *Ithaca, N. Y.*

YOUNG, HOBERT D., junior research engineer, Sinclair Refining Co., *East Chicago, Ind.*

News of Section Meetings

(*Concluded from p. 623*)

Chicken was the entree, and what an entry it made!

Following the dinner the Section moved to the University of Wichita, where Prof. N. Petroff, of the aeronautic section of the faculty of that institution, gave an extemporaneous talk on Wind-Tunnels. This consisted of a short outline of the history of wind-tunnels, the different designs, theory of the tests, workings of the various and sundry parts of the apparatus, methods of computing the values derived from the tests and the reliability of such tests. Professor Petroff emphasized that wind-tunnel tests saved in the past and will in the future save designers many thousands of dollars, since tests predetermine the effectiveness of new wing contours and body or fuselage designs.

This talk was followed by a demonstration of testing of a wing section prepared by the Curtiss-Wright Co., of Wichita, in the 4-ft. tunnel built and operated by the University.

While it was impossible for those looking on to get more than a superficial lesson from the test, they were interested to learn what the local University has to offer in the advancement of the science. Professor Petroff is to be complimented for his efforts.

Notes and Reviews

AIRCRAFT

Airfoil Pressure Distribution Investigation in the Variable-Density Wind-Tunnel. By Eastman N. Jacobs, John Stack and Robert M. Pinkerton. Report No. 353. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; pp. 16. [A-1]

With a view to extending the knowledge of the aerodynamics of lifting surfaces, the distribution of pressure over one section each of six airfoils has been measured in the variable-density tunnel of the National Advisory Committee for Aeronautics. The following airfoils were investigated: N.A.C.A. 85-J, N.A.C.A. 84-J, N.A.C.A. 84, N.A.C.A. M-6, Clark-Y, and R.A.F.-30.

Pressure-distribution diagrams, as well as the integrated characteristics of the airfoils, are given for both a high and a low dynamic-scale Reynolds Number, or VI/v, for comparison with flight and other wind-tunnel tests respectively. The conclusion is reached that the scale effect is very important only at angles of attack near the burble point. Distribution of pressure over an airfoil having a Joukowski section was compared with the theoretically derived distribution of pressure over all of the airfoils and resulted in the development of an approximate method of predicting the pressure distribution along the chord of a normal airfoil for all attitudes within the working range if the distribution at one attitude is known.

Large-Scale Aerodynamic Characteristics of Airfoils as Tested in the Variable-Density Wind-Tunnel. By Eastman N. Jacobs and Raymond F. Anderson. Report 352. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; pp. 32. [A-1]

To give the large-scale characteristics of a variety of airfoils in a form that will be of greatest value, for both airplane design and the study of airfoil characteristics, a collection has been made of the results of airfoil tests made at full-scale values of the Reynolds Number in the variable-density wind-tunnel of the National Advisory Committee for Aeronautics. They have been corrected for tunnel-wall interference and are presented not only on the conventional form but also in a form which facilitates comparison of airfoils and from which corrections can be easily made to any ratio.

An example showing the method of correcting the results to a desired aspect ratio is given for the convenience of designers. In addition, the data have been analyzed with a view to finding the variation of the aerodynamic characteristics of airfoils with their thickness and camber.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor, *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

An Investigation of Airplane Landing Speeds. By Kenneth F. Ridley. Technical Note No. 349. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; pp. 39, figs. 21. [A-1]

This paper describes an investigation of airplane speeds which was made to determine the applicability of accepted aerodynamic theory to the prediction of this particular performance characteristic.

The experimental work consisted in measuring the landing speed of several monoplanes by a new photographic method. The results of these tests, supplemented by available information regarding biplanes, were compared with predictions made in accordance with basic aerodynamic theory. The predictions make use of the fundamental relation between wing loading, lift coefficient and speed of level flight, and the effects of aspect ratio and proximity to the ground on lift-curve slope.

Very satisfactory agreement was found between the predicted and measured values.

Effects of the End Fixation of Airplane Struts. By Alfred Teichmann. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, May 28, 1930. Technical Memorandum No. 582; pp. 25, figs. 7. [A-1]

Load Assumption for Calculating the Strength of Airplanes. From D. V. L. Building Specifications for Airplanes. Technical Memorandum No. 581; pp. 31, figs. 6. [A-1]

Determination of the Maximum Control Forces and Attainable Quickness in the Operation of Airplane Controls. By Heinrich Hertel. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Jan. 28, 1930. Technical Memorandum No. 583; pp. 31, figs. 5. [A-1]

Flight Tests for the Determination of Static Longitudinal Stability. By Hermann Blenk. Translated from 1930 Yearbook of the Deutschen Versuchsanstalt für Luftfahrt. Technical Memorandum No. 584; pp. 11, figs. 16. [A-1]

The foregoing Technical Memoranda concerning airplanes were issued during September, 1930, by the National Advisory Committee for Aeronautics, City of Washington.

Study of Wing Flutter. By Captain C. F. Green and Dr. J. E. Younger. Air Corps Circular Vol. VII, No. 653. Published by the Chief of the Air Corps, City of Washington, 1930; pp. 21. [A-1]

This records a continuation of tests on revised apparatus at the Wright Field wind-tunnel. It is comprised of 21 pages, with two appendixes: (*a*) Laboratory Notes on Wing-Flutter Tests and (*b*) The Flutter of Aeroplane Wings.

Millivolt-Temperature Relation of the Standard Air Corps Iron-Constantin Thermocouple. By G. C. Schleter. Air Corps Circular, Vol. VII, No. 654. Published by the Chief of the Air Corps, City of Washington, 1930. [A-1]

The results of this calibration for the iron-constantin thermocouple show an accuracy of a fraction of a degree for the lower part of the range and 1 deg. for the upper part of the range.

Seaplane Hulls and Floats. By H. M. Garner and L. P. Coombes. Published in *Aircraft Engineering*, August, 1930, p. 193. [A-1]

Considerable improvement has been made in seaplane design, but along aerodynamic rather then hydrodynamic lines, therefore a lamentable ignorance of the water resistance of a seaplane exists. The difficulties in determining the water resistance are great, and the problem is much more complicated than that of determining the air resistance.

The authors give a resumé of the present knowledge of measurements, apparatus, tests, etc., and make suggestions for further research.

(*Continued on next left-hand page*)

KERITE INSULATED WIRE & CABLE CO.
KERITE
in three-quarters of a century of
continuous production,
has spun out a record
of performance
that is
unequalled in the
history of insulated
wires and cables
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO SAN FRANCISCO
DAYS KERITE

For Automotive and Aircraft *Testing*

SOUTHWARK - EMERY Testing Equipment embraces a wide selection of precision instruments for the determination of stress phenomena in materials testing.

The illustration at the left shows a Southwark-Emery 60,000-lb. Universal Testing Machine, which is especially designed for aircraft work.

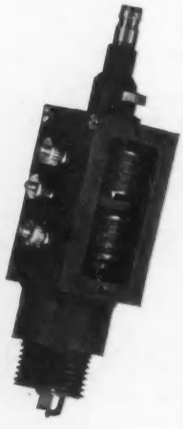
Removable tension head gives clear space for struts or other long specimens to be tested under compression. This machine offers the simplest means for compressive tests on long specimens.

ADDITIONAL INSTRUMENTS OF PRECISION

HUGGENBERGER TENSOMETERS
ELECTRIC TELEMETER
STRAIN GAUGES
DEFORMETERS
PORTABLE TESTERS

60,000-lb. Testing Machine for Aircraft Laboratories

The ELECTRIC ENGINE INDICATOR



With the Oscillograph Recorder this indicator, of flush mounted design, produces a true standing undistorted wave form of pressure characteristics in internal combustion engines.

Write TEST EQUIPMENT DIVISION

SOUTHWARK FOUNDRY AND MACHINE CO. ESTABLISHED 1836 PHILADELPHIA, PA.

Detroit Office—STEEL CITY TESTING LABORATORIES

Notes and Reviews

Continued

Jahrbuch 1930 der Deutschen Versuchsanstalt für Luftfahrt, E. V. Edited by Wilhelm Hoff. Published by R. Oldenbourg, Munich and Berlin, Germany: 688 pp., illustrated. [A-1]

The German Institute for Aeronautical Research introduces its 1930 yearbook with a general summary of the Institute's activities for the 1929-1930 season. Thirty-two organizations now have membership in the Institute, among them governmental departments, the German Automobile Club, the German Aeronautical Chamber of Commerce and the better known aircraft and aircraft-engine manufacturers, companies furnishing aircraft materials and air-transport companies.

Although deploring the hindrance in the Institute's work due to delay in the proposed transfer of its activities into new quarters, the yearbook points out that much has been accomplished. Cooperative relations with other organizations have been established and maintained, trips of study and observation to foreign countries have been made, and the scientific papers, most of which have been published in the *Zeitschrift für Flugtechnik und Motorluftschiffahrt* and its sister magazine, *Luftfahrt-Forschung*, have increased in both scope and number. This year has also seen the publication of bibliographies on aeronautic topics, listing articles selected from about 200 English, German, French and Italian magazines.

Progress made in both national and international standardization is recorded. The test work carried out has included, for aircraft, 79 new types, 94 parts and 722 check tests; and for engines, 7 new types, 318 parts and 849 check tests. Complete reports of the research done are included, grouped in the following sections: aerodynamics, aircraft parts, engines, materials, aerial photography and navigation, radio and electricity, and aircraft operation.

Praktische Erfahrungen mit dem Automatischen Spaltflügel. By G. Lachmann. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Aug. 28, p. 409, and Sept. 15, 1930, p. 440. [A-1]

Slotted wings, states the author in introducing his discussion of the theory and design of this type of structure, were originally conceived as a means of enlarging the speed range of the airplane with the aid of the greater lift imparted by them. Of the two ways of enlarging speed range —decreasing the landing speed and increasing the maximum flight-speed—only the former has been utilized so far. The actual use of slotted wings, however, has for the most part affected landing speeds indirectly, if at all, and has been for the purpose of imparting stability in stalled flight and at large angles of attack. The author looks forward to the further development of the slotted wing as a means of building up a new landing technique, which is especially important for seaplanes and craft designed for shipboard launching and landing.

Herr Lachmann traces the various forms in which the slotted-wing conception has been realized, describes the experimental work necessary in developing a slotted wing for a given wing profile, examines types of control mechanisms, and reports flight tests made with a Moth airplane equipped with a Handley Page slotted wing in which a specially developed instrument was used. He concludes that the slotted wing has successfully fulfilled the claims made for it, and points out where, in his opinion, further developments should lead.

In the discussion, tests are described to show the effect of the slotted wing on aircraft performance, especially the increase of gliding angles at low speed and wing characteristics at large angles of attack. A Focke-Wulf A-28 was the subject of the tests.

(*Continued on next left-hand page*)

QUALITY
BRAND PISTON RINGS

The Piston Ring Co: Muskegon, Mich.

Steering by Gemmer Offers *Six* Advantages

1. "Hour-glass" construction of the worm gear assures easy steering at all positions of the wheel.

2. Two types—worm-and-roller for big cars and worm-and-sector for smaller cars—permits tailoring the steering to each individual make of car.

3. The gears mesh low in the gear case, assuring positive lubrication, even when the lubricant level is low.

4. Fluid lubricant is used, so cold weather cannot affect the steering.

5. Road shocks are minimized by the very designs of the gears themselves.

6. Designed and built by specialists whose work has been standard since the advent of the automobile.

THESE are advantages that interest every motor car *buyer*. They belong in the sales literature and sales manuals of all manufacturers who use steering by Gemmer. Easy steering is an important selling point and all who sell Gemmer-steered cars have a real selling advantage.

SMOOTHER STEERED

WHEN GEMMER GEARED

GEMMER
MANUFACTURING COMPANY...DETROIT

Notes and Reviews

Continued

Aircraft Instruments. By C. J. Stewart. Published by John Wiley & Sons, Inc., New York City, 1930; 260 pp. and index. Price, $5.50. [A-3]

The author has been responsible for some years for the design of aircraft instruments for the British Air Ministry. His papers upon aircraft instruments presented before the Royal Aeronautical Society at various times have been reviewed in the S.A.E. JOURNAL.

In this book the author explains the design, construction, functioning and the fitting of aircraft-instrument equipment, with a view to helping in the maintenance of flying safety and efficiency.

The work is arranged in the form of a textbook for those interested in or studying aeronautics, with an attempt to aid those who may desire to conduct further investigations into instrument design, because the author feels that only by research can important future development of aircraft instruments be assured.

Parachute. By Charles J. V. Murphy. Published by G. P. Putnam's Sons, New York City, 1930; 275 pp. Price, $2.50. [A-3]

In this romance of the parachute, from the tool of the daredevil to the life belt of aircraft, the trial tests of pioneers and painstaking inventors are excitingly described. The narrative, supported by facts, is well written and easy to read.

The Seven Skies. By Harry F. Guggenheim. Published by G. P. Putnam's Sons, New York City, 1930; 216 pp. Price, $2.50. [A-3]

This book provides delightful reading, with some factual value. The author gives a brief history of aviation and the early pioneering period that ended with Lindbergh's never-to-be-forgotten flight. Aviation from that time on has won favor with the public, and the airplane is now regarded as a practical utility. Safety in aeronautics is advancing through the invention and improvement of aircraft apparatus, made possible by the assistance given to aviation research by foundations and other organizations.

Comparison of Aircraft. By Captain P. H. Summer. Published in *Aircraft Engineering—Supplement to Flight*, July 25, 1930, p. 838. [A-3]

Several methods of comparing aircraft have been suggested and are in use, but no entirely satisfactory basis has been evolved. The author of this paper has utilized the Guglielmetti and Tripodi basis, employing speed per horsepower, useful load per horsepower, and ceiling per horsepower. The results are interesting but should be interpreted with much care.

The Challenge de Tourisme International. Published in *The Aeroplane*, July 16, 1930, p. 177. [A-3]

The second annual international competition for touring aircraft, known as the Challenge de Tourisme International, which recognizes ground qualities as well as air qualities, was held in the latter part of July, 1930.

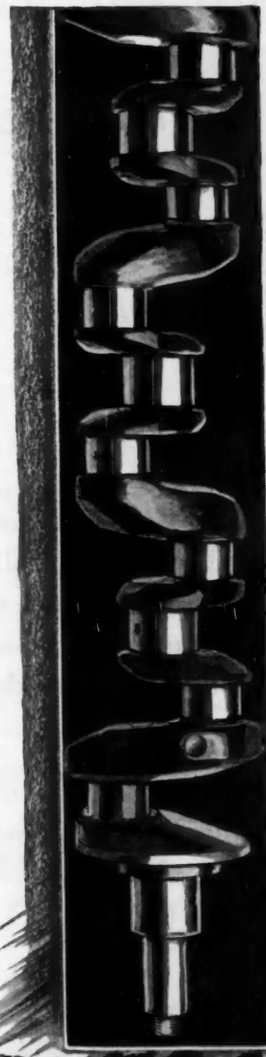
By virtue of a German victory last year, this year's contest was organized by the Aero-Club von Deutschland, and started and finished at Berlin. The course was from Berlin to Brunswick, Frankfurt, Rheims, St. Inglevert, Bristol, London, St. Inglevert, Paris, Poitiers, Pau, Saragossa, Madrid, Seville, Albacete, Barcelona, Nimes, Lyon, Lausanne, Berne, Munich, Vienna, Prague, Breslau, Cracow, Warsaw, Königsberg and Danzig finishing at Templehof, Berlin, a distance of 4680 miles.

The following countries were represented: Germany, 47 competitors; Great Britain, 7; France, 16; Poland, 14; Switzerland, 4; and Spain, 9—97 competitors in all.

(*Continued on next left-hand page*)

IN THE NEW MODELS

Give the Engines the Advantages of Normalized Carbon-Vanadium Crankshafts



ONCE balanced, a Normalized Carbon-Vanadium crankshaft always remains straight and balanced. Wear is less and more uniform. It is very definite assurance of improved engine performance.

Even more than the car owner, the manufacturer benefits when Normalized Carbon-Vanadium Steel is used for crankshafts. It needs no quenching to develop its physical properties—merely a simple normalizing.

The quenching operation is eliminated and internal strains resulting in springing, warping and other defects are absent in Normalized Carbon-Vanadium Steel.

As a result, Normalized Carbon-Vanadium crankshafts require far less cold straightening work, machine more uniformly, run considerably lower in average out-of-balance, and effect many other worthwhile economies in crankshaft production costs.

Complete data on Normalized Carbon-Vanadium crankshafts is available to every engineer, metallurgist and production official. Write us today.

VANADIUM CORPORATION OF AMERICA
120 BROADWAY, NEW YORK, N. Y.

CHICAGO	PITTSBURGH	DETROIT
Straus Bldg.	*Oliver Bldg.*	*Book Tower*

Plants at Bridgeville, Pa., and Niagara Falls, N. Y.
Research and Development Laboratories at Bridgeville, Pa.

VANCORAM

FERRO-ALLOYS of vanadium, silicon, chromium and titanium; silico-manganese, tungsten and molybdenum, produced by the Vanadium Corporation of America, are used by steel makers in the production of high-quality steels.

Normalized Carbon-Vanadium Crankshafts

Require No Quenching *Minimize Cold Straightening* *Eliminate Balancing Problems*

ALUMINUM
SHEET-COILS-CIRCLES

for Drawing and Stamping

In all commercial grades, sizes and tempers.

WE fabricate bright sheet, gray plate aluminum coils and circles in standard and strong alloy grades especially designed to meet the requirements of all stamping and deep drawing operations.

Just write our engineering department for any assistance you need with your problems.

We assure prompt shipment.

Fairmont Aluminum Company

Formerly Fairmont Manufacturing Co.

Fairmont . . . . West Virginia

BRANCH OFFICES AT

52 Vanderbilt Ave. New York — General Motors Bldg. Detroit — Monadnock Block Chicago

A. T. Fitzgibbons, Mgr.., 47 W. Northrup Pl., Buffalo

WAREHOUSE DISTRIBUTORS

Dusommun Corporation, Los Angeles, and San Francisco.
Central Steel and Wire Co., Chicago. Chas. A. Strelinger Co., Detroit.
J. M. & L. A. Osborn Co., Cleveland

Notes and Reviews

Continued

For the second time, Germany, represented by Herr Morzik, won the tour. His score was 427 out of a possible 500, and he proved himself to be in the first rank of all-round pilots. Herr Poss was second in general classification.

Miss Winifred Spooner won the heavy category and gained fourth place, taking 416 points, which is only 11 less than the winner of the trophy. Full marks for speed and reliability were given to H. S. Broad.

Evidently the weather man was not in favor of the contest, because the weather was stormy most of the time. All the pilots declared immediately after they finished that this flight round Europe exacted the greatest efforts from men and machines.

Aeronautical Meteorology—Revised. By Willis Ray Gregg. Published by The Ronald Press Co., New York City, 1930; 440 pp. Price, $4.50. [A-4]

This volume, which contains numerous illustrations, is intended to supply a fundamental understanding of atmosphere and weather conditions for every-day use by the practical operator.

Several sections by meteorological experts in their respective fields are contained in this revised edition, so that information concerning fog, ceiling and visibility, ice formation on aircraft, weather forecasts, instruments and methods of observation, airship meteorology, and the Weather Bureau airway service is right up to the minute.

The essential facts about the upper air and their relation to the development and safety of aeronautics are written in a style to suit the practical operator.

CHASSIS PARTS

Maybach 12-Cylinder Chassis. Published in *The Automobile Engineer*, July, 1930, p. 239. [C-1]

The designer of the Maybach cars is noted for producing a mechanism requiring the minimum of attention to use. His cars have not sold very well outside Germany because they embody so much unconventional design. The redesigned chassis is interesting and less unorthodox than its predecessors.

Experience with aircraft engines has led to revised views upon piston speeds, torque, flexibility, and crankshaft balance, and a change-over to a 12-cylinder engine. The power is transmitted through a single-plate clutch to a three-speed transmission, a Maybach overspeed gear being incorporated in the latter. For the final drive, helical bevel gears are employed. A bevel type differential is used.

The power unit consists of two banks of six cylinders arranged in V form at 60 deg. to each other. The cubic capacity of the engine is almost identical with that of the six-cylinder model, but the engine has none of the unorthodox features that were embodied in the earlier model.

The author explains in detail and illustrates with numerous designs the clutch, transmission, rear axle, front axle, steering mechanism and frame. He is convinced that the car is capable of giving an excellent all-round performance.

Independent Springing Marks Progress toward Perfection in Riding Comfort. By P. M. Heldt. Published in *Automotive Industries*, Sept. 20, 1930, p. 400. [C-1]

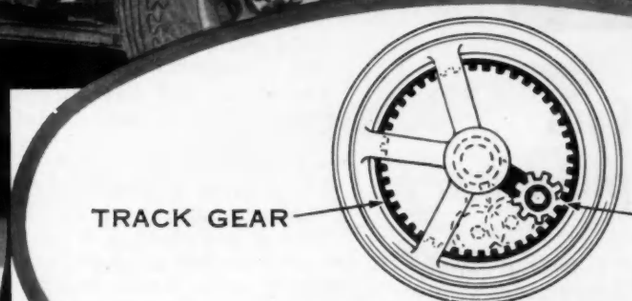
Three of the series of five articles by Mr. Heldt describing how springs take the place of a large portion of axles in a number of cars now in production have appeared in the above magazine to date.

The principle of independent springing was first made use of by the designers of the Sizaire-Naudin car. Although this principle has been known for more than 25 years, very little experience has been accumulated to guide the engineer who starts out to design such a system.

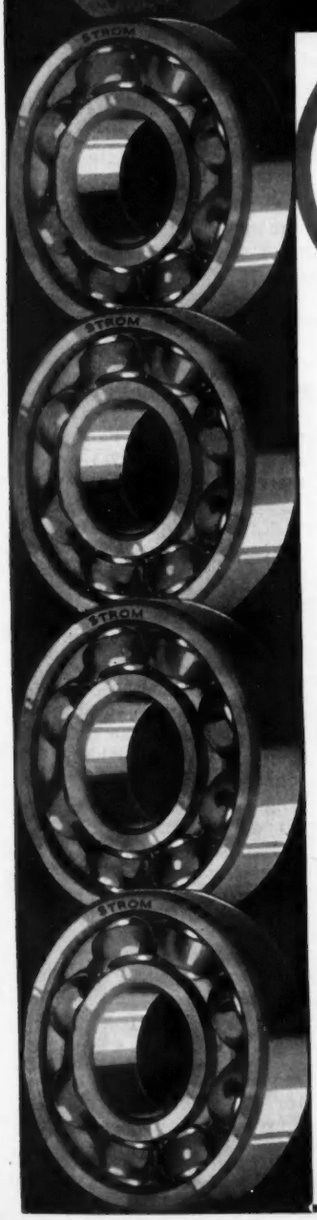
(Continued on next left-hand page)

The Relay Oscillating Rear Axle

Saves 3¢ per average mile



PRINCIPLE OF RELAY REAR AXLE.
The pinion "A" is free to oscillate in the track gear "B", (as shown by the dotted lines)—cushioning the blows of the road.



Strom Ball Bearings ~ *on Jackshaft, Axle & Pinion*

Much of Relay Motor Truck efficiency is due to their oscillating rear axle. "This axle," Relay claims, "gives the truck a SUPER-DEFENSE against road impacts and tire wear—saving a total of 3c per average mile."

Operating economy is not the lone merit of this axle. Adequate safety factors for each part, give ample protection against heavy loads — long hauls and frequent starts and stops.

Relay Trucks use Strom Ball Bearings on Axle, Jackshaft and Pinion. Ball Bearings in these important locations protect against wear and adjustments—decrease repair bills and maintenance stops—and hold shafts and gears in rigid alignment.

STROM BEARINGS CO., Div. Marlin-Rockwell Corp., 4535 Palmer St., Chicago, Ill.

Strom BALL BEARINGS

Only an Artist Can Create a Masterpiece

GIVEN a piece of marble or a mass of modeling clay, anyone with a little artistic ability can produce something that looks like a human figure.

But only a Michelangelo or a Rodin can create in stone or bronze a masterpiece that will endure through the ages.

A storage battery is a product of science rather than of artistry. But it is a product of skill and experience as well. With some knowledge of the subject, anyone can build a storage battery.

But only an organization that for 42 years has designed and built storage batteries for every purpose, can produce the Exide Battery. And only a product like the Exide can continue to satisfy millions of motorists as Exides have done, since the earliest days of automotive history.

Exide
BATTERIES

The Electric Storage Battery Company
The World's Largest Manufacturers of Storage Batteries for Every Purpose
Philadelphia
Exide Batteries of Canada, Limited, Toronto

Notes and Reviews
Continued

Successful application of independent springing is found in several foreign cars; for example, the Lancia Dilambda, Tracta, Roehr, Alvis and Bucciali. These embody different types of design, four of which Mr. Heldt describes briefly as:

(1) Steering knuckles sliding in or on vertical guides on brackets secured to the chassis frame, or to the body if no chassis frame is used

(2) Steering heads, on which the knuckles are swiveled or the wheel spindles are supported, carried on the end of transverse leaf-springs which are anchored at the middle of the frame on either a cross member or the final-drive housing

(3) Axle housings made in halves, each half being pivotally supported at its inner end so that it can swing in a vertical plane, the load being transferred to its outer end by means of a leaf spring anchored to the frame

(4) Axle spindles or steering heads mounted on lever arms extending parallel with the frame side-members and having bearings on the frame.

The author will continue this discussion of independent springing in later issues of *Automotive Industries.*

Front-Axle Design. By R. Dean-Averns. Published in *The Automobile Engineer,* August, 1930, p. 299. [C-1]

This is a survey of the stresses to which the front axle of a motor-vehicle is subjected. The author discusses the problems encountered in axle design, the effect of shocks imparted to the chassis in different conditions of speed and road, the important relationship of the spring centers to the disposition of axle weight, the gyroscopic effect of the front wheels, axle dimensions, diameter of the swivel-arm bearing-spindle, and the influence of tool marks on the fatigue limit of the material.

EDUCATION

Traffic Officers' Training Manual. By Clarence P. Taylor. Published 1930 and sold by the National Safety Council, 20 North Wacker Drive, Chicago, Ill. The 225-page manual, including index, is of pocket size—4½ x 7¼ in.—and includes 11 tables, 5 charts and 10 diagrams, as well as other miscellaneous tabulated data. [D-4]

The nature of the traffic problem is discussed first and the subsequent chapters go into details of such subjects as the control needed at intersections, the parking problem, and the handling of crowds which gather at processions, fires, disasters, sporting events and the like.

Mechanical defects of headlights and other equipment are commented upon constructively, as are also miscellaneous law-enforcement problems and the methods of handling the violators of traffic-control rules. A chapter is devoted to legislative, engineering and scientific methods that apply to regulation through educational and other various means. The obtaining and making proper use of statistics through special investigations of traffic risks and the most suitable policies for accident investigation are stated.

The investigation of criminal cases and the methods of Court procedure are other subjects treated, as well as human relationships in departmental and interdepartmental work, and friendly dealings with the Press and with the Public. Aviation-law enforcement is treated in an appendix.

Besides being a book that provides a complete background of traffic-control fundamentals for traffic-officers' use, it has a direct application to the problem of training all drivers—but especially those of fleets of motor-vehicles—

(*Continued on next left-hand page*)

One of the five, "Miss Silvertown", "Wasp"-powered Lockheed Vega, piloted by Mr. Lee Schoenhair

SRB Ball Bearings

...used in the "Wasp" and "Hornet"-Powered Lockheed Vega Fleet on record trip from Los Angeles to Chicago (1760 miles) in less than 10 hrs.

IN the five Pratt and Whitney "Wasp" and "Hornet" engines that powered the ships of Post, Goebel, Schoenhair, Brock and Turner, in the memorable non-stop cross-country Derby, on August 26th, SRB Ball Bearings were standard equipment at important points.

SRB Ball Bearings typify in capacity, material, workmanship and dependability all that is outstanding in Ball Bearing design. Naturally they are in such world-known engines as Wright, Curtiss, Warner, Lycoming and others.

This same responsible performance is equally valuable in the automotive field.

Ball SRB Bearings

STANDARD STEEL AND BEARINGS INCORPORATED
Plainville DIVISION OF MARLIN-ROCKWELL CORPORATION *Connecticut*

3014A

Safeguarding
Great American Names

B. C. A. Ball Bearings are used in practically all of the finest motor cars made in America. For over 30 years we have quietly accepted this trust and fulfilled our responsibility to the automotive industry, fully aware of the fact that every car can only be as good as the parts which go into its assembly. B. C. A. Annular and Thrust Ball Bearings today are helping to safeguard the automotive industry of the future.

Notes and Reviews

Continued

in that it enables drivers to understand the broad subject of traffic control more clearly and gives them an opportunity to cooperate with traffic officers, rather than to treat them as enemies. A prominent feature is the complete lists of books bearing on traffic regulation, given at the end of each of the 14 chapters, so that readers can study out any special line farther.

The author is an Albert Russel Erskine Research Bureau Fellow at Harvard University, and was formerly in charge of traffic work for the Berkeley, Calif., Police Department. Miller McClintock, director of the Erskine Bureau, is the editor. The "Foreword" is by August Vollmer, formerly chief of police, Berkeley, Calif., and now professor of police administration at the University of Chicago.

ENGINES

Alterations and Tests of the Farnboro Engine-Indicator. By John H. Collins, Jr. Technical Note 348. Published by the National Advisory Committee for Aeronautics. City of Washington, 1930; pp. 14, figs. 5. [E-1]

The Farnboro electric indicator was tested as received from the manufacturers, and modifications were made to the instrument to improve its operation. The original design of disc valve was altered so as to reduce the mass, travel, and seat area. Changes made in the recording mechanism included a new method of locating the top-center position on the record. The effect of friction on the motion of the pointer while taking motoring and power cards was eliminated by providing a means of putting pressure lines on the record.

The modified indicator gives a complete record of the average cyclic variation in pressure per crank degree for any set of engine-operating conditions that can be held constant for the period of time required to build up the composite card. The value of the record for accurate quantitative measurement is still questioned, although the maximum indicated pressure recorded on the motoring and power card checks the readings of the balanced-diaphragm type of maximum-cylinder-pressure indicator.

The Efficiency of Air-Filters for Internal-Combustion Engines. By W. E. Gibbs, A. Brandt and M. L. Nathan. Published in *Engineering*, Aug. 22, 1930, p. 221. [E-1]

An automobile cannot be driven along any road without coming in contact with dust. Even if the concentration of dust particles in the air is relatively low, the volume drawn through the carbureter will result in a measurable quantity of dust getting into the engine. Experimenters have found that the finer particles do the more damage, and there is evidence, write the authors, that the carbon deposition in the cylinders is more if the air contains solid particles.

There are numerous types of air-filter that employ one or more of the following principles: electrostatic precipitation, washing, mechanical separation by straining through gauze or felt, centrifugal force. With most types the efficiency falls off rapidly as the size of the dust particles is reduced.

Tests were made with a Visco and a Cyclone filter. The results show that the efficiency of the Visco filter is uniformly higher than that of the Cyclone filter, according to the authors, and that it is independent of particle size. This superior efficiency is credited to the small radius of the curvature imparted to the air-stream.

Some Characteristics of Nozzles and Sprays for Oil Engines. By A. L. Bird. Paper presented at the Second World Power Conference, Berlin, June, 1930. [E-1]

The author gives in detail the results of experiments carried on by his pupils and himself at the engineering laboratory in the University of Cambridge, England.

(*Continued on next left-hand page*)

QUIET PLEASE

More and more the motoring public is becoming noise conscious. Quiet is today one of the essential refinements expected and demanded in the modern motor car.

Rusco Durak Brakeshoe Liners offer a means of guarding against one of the most common and one of the most annoying forms of noise nuisance—squeaking brakes. Brakes lined with Durak apply easily, smoothly, silently. They give quick-stop efficiency in wet weather as well as in dry.

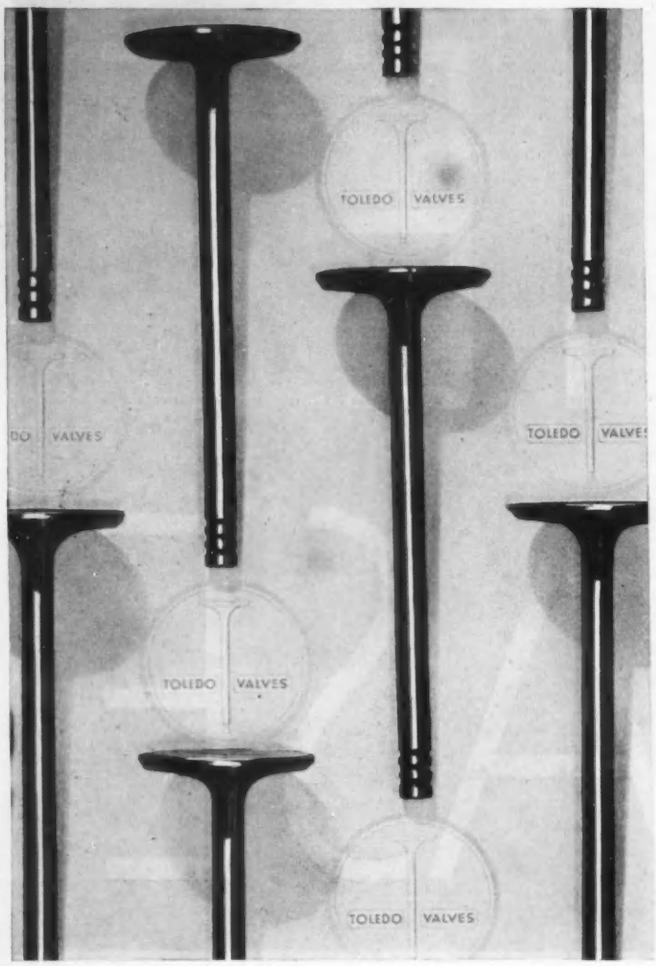
Durak is manufactured by a special patented process. It contains 50% more asbestos than the ordinary brake lining—is built with the exactness of a bearing—and is impervious to the action of oil and water.

Because of its sturdy, rigid construction, accurate and lasting adjustment can be made at time of installation, thus insuring dependable b r a k e performance without frequent servicing.

We shall be glad to send to responsible executives in the motor car industry, without charge or obligation, a set of Durak Liners for a personal test. In writing, state make of car, year and model. Address Department B-69, The Russell Mfg. Company, Middletown, Conn. In Canada, The Russell Mfg. Company, Ltd., St. Johns, P. Q.

RUSCO DURAK *Brakeshoe* LINERS

ONE PIECE FORGED STEEL
VALVES OF FINEST QUALITY



Toledo "Super-Forged" Valves

Made of a special chromium nickel aluminum alloy which does not pit or increase in hardness. Toledo Valves do not wear the valve seat.

THE TOLEDO STEEL PRODUCTS COMPANY
TOLEDO, OHIO, U. S. A.

New York: 17 West 60th Street
Atlanta: 279 Ivy Street, N. E.
Oakland: 3106 Adeline Street
Chicago: 1225 So. Wabash Ave.
Kansas City: 14th and Oak Street
Los Angeles: 216 N. Alameda St.

TOLEDO
VALVES

TOLEDO STEEL

TOLEDO BLUE PRINT BOLTS and
TOLEDO BLUE PRINT BUSHINGS

Notes and Reviews

Continued

Aircraft-Engine Trends. By Harold Caminez. Published in *Aviation Engineering*, August, 1930, p. 9. [E-1]

The author goes into detail concerning the number of improvements that may be effected in air-cooled engines, particularly with regard to cylinder cooling, and questions whether they can be made fully to meet commercial requirements.

In his opinion the radial air-cooled engines probably will remain the most popular type for the present. The most promising field for new engine designs now seems to be in small powerplants for glider use and large powerplants for big transport airplanes. For the former, the tendency appears to be in favor of two-cylinder opposed air-cooled engines; while, for the latter, the 12-cylinder V-type liquid-cooled engine is growing in popularity. Return to favor of engines of the latter type for transport aviation should influence new development in liquid-cooled engines for the smaller airplanes.

Following Combustion in the Gasoline Engine by Chemical Means. By Lloyd Withrow, W. G. Lowell and T. A. Boyd. Published in *Industrial and Engineering Chemistry*, September, 1930, p. 945. [E-1]

The results of this study indicate (*a*) that a definite combustion zone exists which passes through the charge of gasoline and air in the engine at finite velocity; (*b*) that the combustion zone travels faster through the middle portions than along the side walls of the combustion space; (*c*) that during normal combustion in the engine a comparatively narrow combustion zone, within which the oxidation reaction completes itself as far as the air present permits, proceeds from the spark-plug through all parts of the charge at a measurable rate of speed; and (*d*) that the disturbance known as detonation occurs in that part of the charge which burns last.

Notes on Heavy-Oil-Engine Research. By Alan E. L. Chorlton. Paper presented at the Second World Power Conference, Berlin, June, 1930. [E-1]

The trials reported upon were concerned with the performance of complete installations, both ashore and afloat. The tests ashore included exhaustive experiments at various loads and speeds to determine a field or chart of fuel consumption and mechanical efficiencies for each engine. The tests at sea were confined to the determination of transmitted and thrust-power horsepower and the ability and speed with which the vessels could be maneuvered.

MATERIAL

Compression Pressure Is Controlling Factor in Inducing Engine Knock. By Sandor D. Rubenz. Published in *Automotive Industries*, July 5, 1930, p. 20. [G-1]

A single-cylinder Liberty engine was used in the tests recorded. In this engine the tendency to knock was found to be greater with two spark-plugs than with one, but the type of spark-plug had no influence upon the initiation of knock.

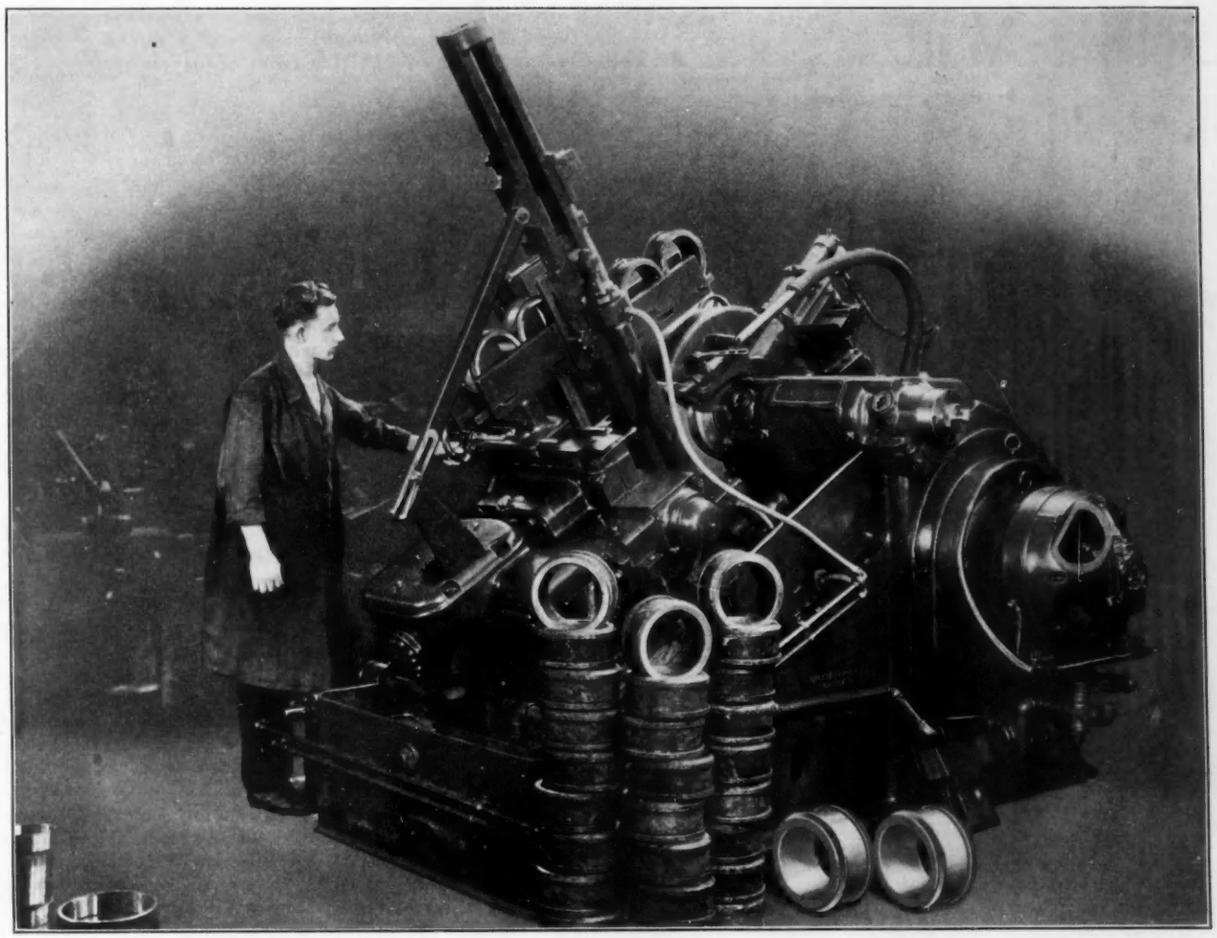
If these and similar tests are to be of real value to the pilot in determining the amount of throttling necessary for safe operation with any fuel, provided he knows at what speed he can operate with equal safety with another fuel, it is necessary that all fuels sold for aviation use at flying-fields be certified and rated as to antiknock value on some standard basis.

Volatile Liquid Fuels. By H. C. Dickinson. Paper presented at the Second World Power Conference, Berlin, June, 1930. [G-1]

Dr. Dickinson reviewed the work of the Cooperative Fuel Research Committee from the time of its inception until

(*Continued on next left-hand page*)

IN THE SPIRIT OF THE AGE



This machine, possibly the largest of its kind in existence, is producing nine pieces where one was produced before.

Thus, is modern equipment at the Rollway plant doing its share to better precision and reduce cost to the user.

ROLLWAY BEARING
COMPANY INCORPORATED
SYRACUSE NEW YORK
ROLLWAY CYLINDRICAL ROLLER BEARINGS

MECHANICS UNIVERSAL JOINT

"Built as only Mechanics can build"

The Mechanics Universal Joint is becoming more and more the specified universal joint for leading passenger cars and trucks. It is gaining its logical and merited position with a steady progressiveness that is far in advance of all expectation. Its hegemonical leadership can not be denied.

Mechanics Universal Joints are built to a perfection standard excelled by no other manufacturer of standard equipment joints.

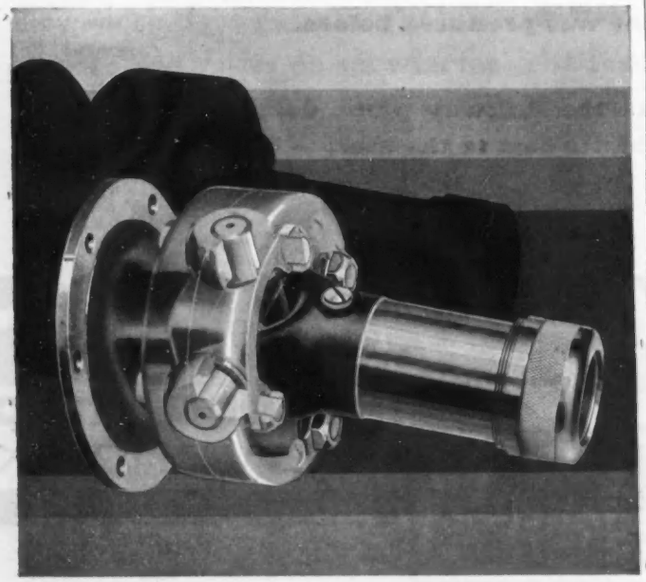
Mechanics Universal Joints retain their lubricant . . . an essential feature of the better performing joint. Built as only Mechanics can build. Specify Mechanics Universal Joint.

MECHANICS UNIVERSAL JOINT COMPANY
ROCKFORD, ILL.

Sales Representatives: C.A.S. Engineering Co. 5-139-140 General Motors Bldg. Detroit, Mich.

Export Representatives: Benjamin Whittaker, Inc. 114-118 Liberty St. New York, N. Y.

Foreign Representatives: Benjamin Whittaker, Ltd., Victoria House, Vernon Place, London, W. C. 1, England.



Notes and Reviews

Continued

the present. He discussed enthusiastically the various projects undertaken; for example, Fuel Volatility and Economy, Dilution of Crankcase Oil, Engine Starting, Fuel Volatility, Engine Acceleration, and Vapor Lock.

In addition, he discussed the potential sources of motor fuel and the modern processes which virtually double the average yield of gasoline from crude oil.

The Volatility of Motor Fuels. By George Granger Brown. Engineering Research Bulletin No. 14. Published by the University of Michigan, 1930. Price, $1. [G-1]

The conclusions of the author are: (*a*) The ease with which a motor will start, the length of time required to warm up, and the character of its general performance are almost wholly dependent upon volatility of the fuel as indicated by the A.S.T.M. distillation curve; (*b*) The 10-per cent point is related to the lowest engine-temperature at which satisfactory starting can be obtained and the lowest mixture-temperature at which the car can be operated; (*c*) The 35-per cent point is related to the lowest mixture-temperature at which satisfactory performance can be obtained during the warming-up period and therefore determines the length of time necessary to warm up the motor; (*d*) The 65-per cent point is related to the lowest mixture-temperature at which perfect performance can be obtained.

For these reasons 10, 35 and 65-per cent points should be low to assure satisfactory starting, warming-up and general performance. The 90-per cent point, however, should not be so low as to indicate a dry mixture, for this means loss in power or acceleration with many modern cars equipped with heated manifolds and accelerating devices. The vapor pressure of the fuel or the 10-per cent point should not be so low as to indicate trouble from vapor lock.

The investigation reported in this bulletin represents a research program financed by the Natural Gasoline Association of America, which extended from June, 1926, to May, 1930. During this time the author, with other experimenters, published five papers on different phases of the research in *Industrial and Engineering Chemistry*. These articles were: I—Equilibrium Volatility, by G. G. Brown and E. M. Skinner; II—Starting Volatility, by G. G. Brown, Charles L. Nichols and Paul Bigby; III—Effective Volatility under Driving Conditions, by Jarvis E. Miller and G. G. Brown; IV—Relation between Atmospheric Temperatures, Fuel Volatility and Engine Performance; V—Vapor Pressure and Vapor Lock.

The first of this series of articles was reviewed in the July edition of the S.A.E. JOURNAL.

Temperature Coefficient of the Modulus of Rigidity of Aircraft-Instrument Diaphragm and Spring Materials. By W. G. Brombacker and E. R. Melton. Report No. 358. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; pp. 16. [G-1]

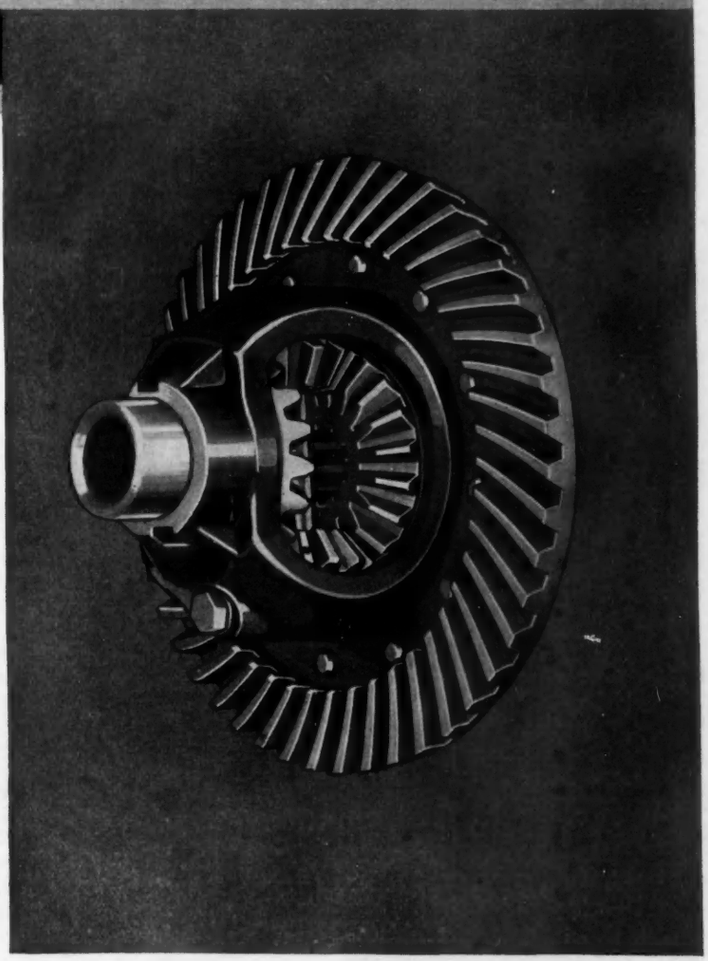
Experimental data are presented on the variation of the modulus of rigidity, in the temperature range —20 to +50 deg. cent., of a number of metals which are of possible use for elastic elements for aircraft and other instruments. The method of torsional pendulum was used to determine the modulus of rigidity and its temperature coefficient for aluminum, duralumin, Monel metal, brass, phosphor-bronze, coin silver, nickel silver, three high-carbon steels and three alloy steels. The temperature coefficient m is defined by the relation

$$m=(1/G_o)\ (dG/dT)$$

in which G and G_o are the moduli of rigidity at the temperatures T and O deg. cent. The differential dG/dT was found to be a constant except for two metals. The effect of heat-treatment on m was determined for a number of the materials. It was observed that tensile stress affected the values of the modulus by amounts of 1 per cent or less.

(*Continued on next left-hand page*)

DIFFERENTIALS TRANSMISSIONS STEERING GEARS AXLES



NEW PROCESS — has pledged itself to sustain the ideals, and the broad progressive policies, of the companies it serves by becoming an integral part of those companies — observing the same high standards of craftsmanship which those companies expect from their own employees.

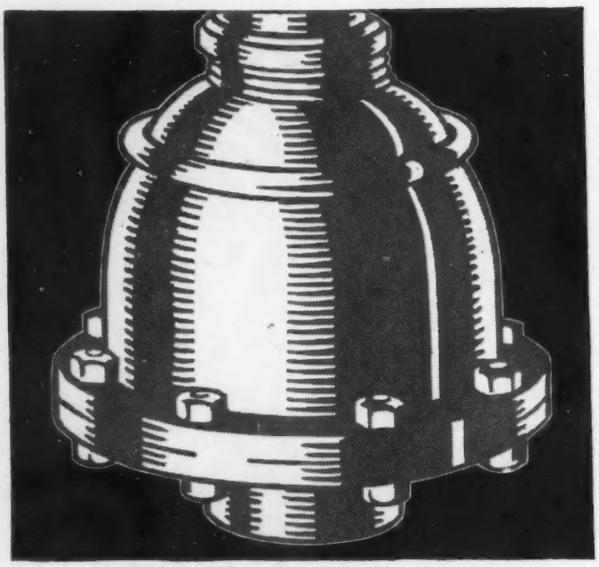
ESTABLISHED NEW PROCESS NP GEARS 32 YEARS

NEW PROCESS GEAR CO., INC. SYRACUSE, NEW YORK

SPICER

PROPELLER

ASSEMBLIES



With the most modern manufacturing facilities at our command, we are able to combine high production with excellent workmanship—resulting in a propeller shaft that leads the world.

ASSOCIATED Spicer COMPANIES

CLUTCHES-TRANSMISSIONS
BROWN-LIPE GEAR CO.
SYRACUSE NEW YORK

FRAMES and STAMPINGS
PARISH PRESSED STEEL CO.
READING PENNA.

UNIVERSAL JOINTS
SPICER MFG. CORP.
TOLEDO OHIO.
SALISBURY AXLES

Notes and Reviews

Continued

The Effect of Temperature upon the Torsional Modulus of Spring Materials. By F. P. Zimmerli, W. P. Wood and G. D. Wilson. Paper presented at the 33rd annual meeting of the American Society for Testing Materials, Atlantic City, N. J., June 23 to 27, 1930. [G-1]

Simple torsion was applied to wire sections in a specially constructed furnace. The results were as follows:

(1) A general downward trend in the moduli as temperature increased

(2) With temperature increases, alloy steels and nonferrous metals show no regular change in their moduli. A regular decrease in modulus was shown in carbon steels through the temperature range employed.

(3.) Stainless steel has a lower modulus at all temperatures than any other steel.

(4.) Monel metal shows great superiority at all temperatures to phosphor-bronze and brass.

(5.) Cold work causes an apparent increase in the modulus. Supplementary tests show that "trapped" stresses in the cold-worked metal neutralize part of the applied stresses, making the modulus appear higher than it really is.

MISCELLANEOUS

The Practice of Research. By J. F. Alcock and H. S. Glyde. Published in *Aircraft Engineering*, September, 1930, p. 227. [H-1]

The firm of Ricardo & Co. was founded in England in 1915 for the carrying out of consultative and research work, particularly in connection with high-speed internal-combustion engines. At that time its main activities were of a military nature, such as the evolution of several engines used for tank propulsion. After the war, similar work was undertaken for private concerns.

The firm does not manufacture in any ordinary sense, its only material output being a few special engines intended purely for research and sold mainly to universities, oil companies and similar bodies. Apart from this, the firm's activities consist of design and experimental work for individual clients, general research work on gasoline and oil engines, on fuel, lubricants and allied questions, and consulting work generally.

The experimental work consists of fundamental research on basis problems, such as combustion and supercharging; testing engines designed for commercial purposes; and research on fuels and lubricants.

The authors describe in detail the wide variety of test equipment; for example, dynamometers, apparatus for measuring air flow and temperature, water-cooling, air-cooling, fuel consumption, and speed, and indicators of various types.

This is the first of a series of articles concerning the noted laboratory.

The Second World Power Conference. Published in *Engineering*, June 20, 1930, p. 804. [H-3]

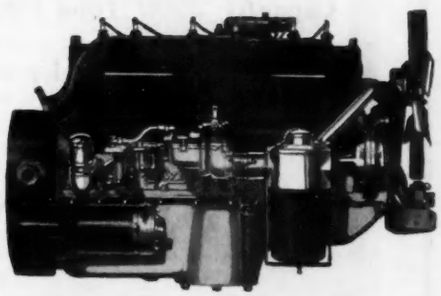
On June 15, representatives, official delegates, and ordinary participants from 55 countries met in Berlin at the Conference to discuss power in all its aspects, scientific, industrial and commercial. Numerous important papers upon all conceivable subjects relating to power were presented.

The remarks of the various speakers who took part in the discussions were translated into German, English and French. The interpreters spoke through a series of microphones, each seat in the auditorium being equipped with a head set and with change-over and volume-control switches, so that any of the three languages, including that which the speaker himself was employing, could be heard.

(*Continued on next left-hand page*)

Hercules Engines Help Operators Win Bus Maintenance Awards

In a field where operating conditions are exacting—where routine servicing pays dividends—Hercules Engines have effected many economies. Out of five possible awards in Bus Transportation's "progress in maintenance" competition, three were won by operators of bus fleets exclusively or partially Twin Coach—powered by Hercules Engines built to Twin Coach specifications. Many leading manufacturers of commercial cars and trucks have also recognized Hercules' superiority in the field of heavy-duty power—have adopted Hercules Engines as standard equipment.



HERCULES MOTORS CORPORATION, CANTON, OHIO, U. S. A.

New York Office: New York, N. Y. Mid-Continent Office: Tulsa, Okla. West Coast Office: San Francisco, Cal.

Distributors: Smith-Booth-Usher Co., Los Angeles, Cal.; Edward R. Bacon, San Francisco, Cal.; F. C. Richmond Machinery Co., Salt Lake City, Utah; Worthington Machinery Corp. of Oklahoma, Tulsa, Okla.; Norvell-Wilder Supply Co., Beaumont, Texas; Bovaird & Co., Bradford, Pa. European Distributor: Automotive Products Co., London, Berlin, Vienna.

HERCULES ENGINES

DROP and UPSET FORGINGS

Backed by
47 Years' Experience

AUTOMOBILE
TRUCK
TRACTOR
AEROPLANE
MISCELLANEOUS

Complete Heat Treating and Laboratory Facilities

Capacity 2500 Tons Per Month

Any Type—Any Size—Up to 500 Lbs.

UNION SWITCH & SIGNAL CO.

Drop Forge Division

SWISSVALE, PA.

Notes and Reviews

Continued

It was felt that the most important result of the Conference was the personal contacts established among so many experienced specialists from all over the world.

The Conference has shown that the supply of mechanical power, light and heat must, in the long run, lead to a reduction of unemployment and has opened up great perspectives for the future, not only in the scientific and technical but in the economic and sociological fields.

Techno-Diktionär. By Hubert Hermanns. Published by Hubert Hermanns, Berlin, Germany; 411 pp. [H-3]

This general foreign-language technical dictionary is in three parts, the key lists being in German, English and Italian. In addition to the simple word listings, it contains a number of compound words and phrases and is designed specifically to assist the engineer and business man in reading periodicals and books in foreign languages. It is a second edition, enlarged and revised from the original work.

Réflexions sur un Voyage aux U.S.A. By Ch. Waseige and Perrot. Published in the *Journal de la Société des Ingénieurs de l'Automobile*, July, 1930, p. 1074. [H-3]

A generous and cordial evaluation of America is voiced in this record of general impressions received by the authors in their visit to this Country with the delegation of French automobile engineers. To sum up, they say, American industrial progress has been so rapid as to outstrip France in all branches, except in a few rare instances. The importance of this fact is stressed by the pronouncement that industrial development is the absolute index of the power of a nation. More astonishing to the authors, because less anticipated, was America's social, cultural and scientific advancement. Art and industry have here gone hand in hand.

Americans, write the authors, are democratic, cooperative, good-humored, ambitious, energetic, imbued with pride of workmanship and easily amenable to discipline that is conceived to be imposed for the general good.

About automotive progress the authors are less complimentary. They state that American cars, both the expensive and the cheap, have the same virtues and faults; their fuel consumption is high, they cannot hold the road at high speeds, their steering is uncertain under these conditions, and their suspension is haphazard. One high-priced model tested by them is excepted from the general condemnation.

Addressing themselves to their own nation, the French engineers urge that Frenchmen rouse themselves to actualities, lest they find themselves servants of an industrial nation. They advise cooperation with American industry; the study of English, which seems to be destined for the rôle of a universal language; and, for engineers, less attention to perfection on paper and more to the satisfaction of the customer. They comment particularly on the esteem which America evidences for France and the cordiality of their reception in this Country.

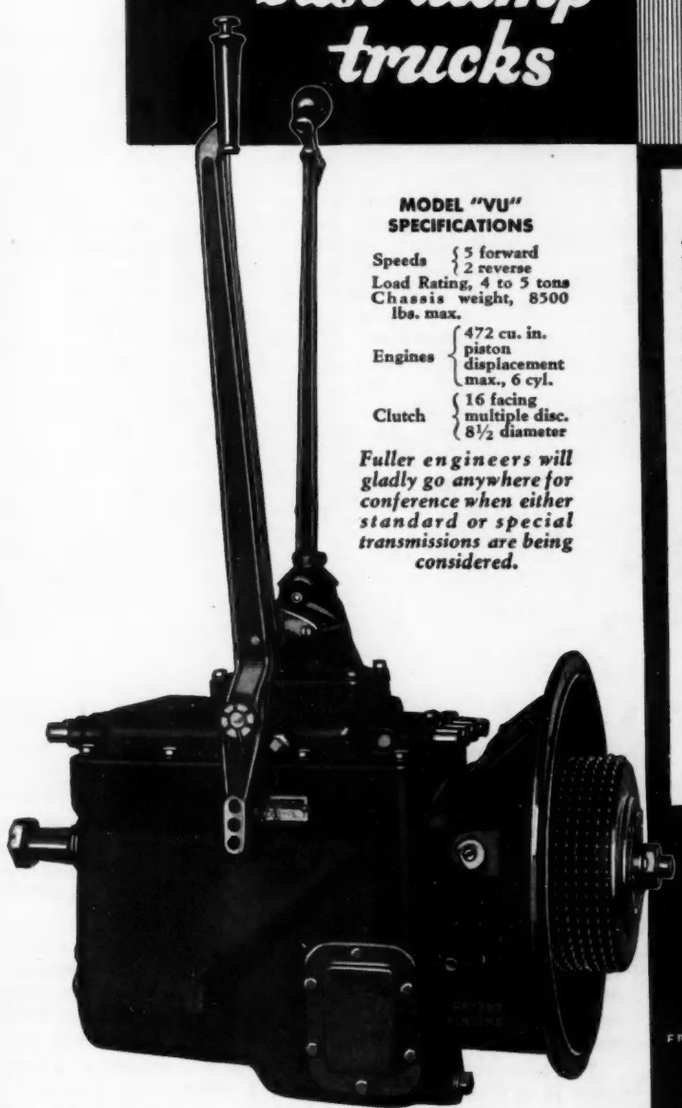
Hindman Tolerance System Proposes To Allow for Interchangeability of Parts. By W. L. Hindman and Athel F. Denham. *Automotive Industries*, Aug. 16, 1930, p. 232. [H-5]

Specifications for tolerance on drawings have undergone changes in past years. The former method of specifying the basic size with plus and minus tolerance has largely been replaced by the "limit" method, in which both the maximum and minimum sizes are specified. The plan designed should be equally adapted to press fits as well as running fits.

The ability of a system such as the Hindman to take in every conceivable fit used in actual production and the

(Concluded on next left-hand page)

why is the UNIT "VU" TRANSMISSION especially adapted to short wheel-base dump trucks ?



MODEL "VU" SPECIFICATIONS

Speeds	5 forward, 2 reverse
Load Rating, 4 to 5 tons	
Chassis weight, 8500 lbs. max.	
Engines	472 cu. in. piston displacement max., 6 cyl.
Clutch	16 facing multiple disc. 8½ diameter

Fuller engineers will gladly go anywhere for conference when either standard or special transmissions are being considered.

A SHORT WHEEL-BASE means a short propellor shaft. A short propellor shaft usually means sharp angle attachment to the transmission . . . with the angle increasing in ratio to the distance the transmission is from the motor. The only thoroughly successful short wheel-base transmission line-up is with an integral coupled unit such as the Fuller Unit "VU" Transmission. This Unit is especially adapted to dump trucks and tractors . . . because it is mounted integral with the motor and attaches directly to the bell housing, without intermediate shafting. This straightens out the propellor shaft angle, thus increasing operating efficiency and lowering maintenance costs.

This is one of many Fuller "Unit" innovations that make Fuller transmissions desirable for HEAVY DUTY SERVICE.

FULLER & SONS MFG. COMPANY
Division of Unit Corporation of America
Bankers Building Milwaukee, Wis.

FULLER
STANDARD AND SPECIAL
TRANSMISSIONS
FROM ROUGH BILLET TO FINISHED PRODUCT
Fuller

it peels

Just as substantial as a solid shim with the advantage of the PEELING feature.

CARS come and cars go. Designs change. So do models and mechanical details. But—during all the years Laminum still remains *the* material for shims . . . nothing has yet been devised that can equal Laminum in performance and efficiency.

Laminum comes in sheets 6" x 36", or we will make shims to your own B. P. S. Send for a sample of Laminum and complete details.

LAMINATED SHIM COMPANY, INC.
244—14th St., Long Island City, N. Y.
Detroit Representative: 405 *Curtis Bldg., Detroit, Mich.*

LAMINUM

Notes and Reviews

Concluded

provision of a definite means of gradually eliminating the unnecessary varieties are much to be desired.

MOTOR-TRUCK

Calibrations of Accelerometers for Use in Motor-Truck Impact Tests. Reported by J. A. Buchanan. Published in *Public Roads*, July, 1930, p. 81. [K-1]

This is a summary of a detailed report on a cooperative investigation made by the United States Bureau of Public Roads and the Bureau of Standards. The purpose of the investigation was to ascertain the accuracy and other characteristics of such instruments as had been used, or were proposed for use, in the motor-truck impact investigation conducted by the Bureau of Public Roads with the cooperation of the Rubber Association of America and the Society of Automotive Engineers.

The report deals with an investigation of three methods of measuring accelerations due to motor-truck impact. The methods are: (*a*) by analysis of records from the displacement-time apparatus, (*b*) by means of the cantilever-spring contact accelerometer, and (*c*) by means of the coil-spring accelerometer.

These instruments are described and the theory involved in the use of each is given. The calibrations included static tests, dynamic tests on a machine producing simple harmonic motion having periods and amplitudes analogous to those of motor-truck impact, and dynamic tests with a motor-truck on a reaction wheel closely simulating road operating-conditions. Data are given showing the agreement between basic measurements of acceleration, the relation between theory and practice in the case of the coil-spring accelerometer, the dispersion to be expected in coil-spring accelerometer data, and the estimation of impact periods. Comparisons are made which show the effect that new calibration data would have on impact forces computed by original calibrations. The report closes with a statement of conclusions reached as a result of the investigation.

National Motor-Truck Analysis. Published by General Motor Truck Co., Pontiac, Mich., 1930, 44 pp. [K-1]

In an endeavor to carry on its research study on motor-trucks, the General Motor Truck Co. mailed thousands of questionnaires to truck owners. Answers were received from all States, from large and small cities and towns, from firms in all lines of business, and from owners of great fleets down to owners of only one or two trucks.

The results of the survey are of value to truck owners in comparing their own costs and experiences with National averages of others in their line of business.

PASSENGER CAR

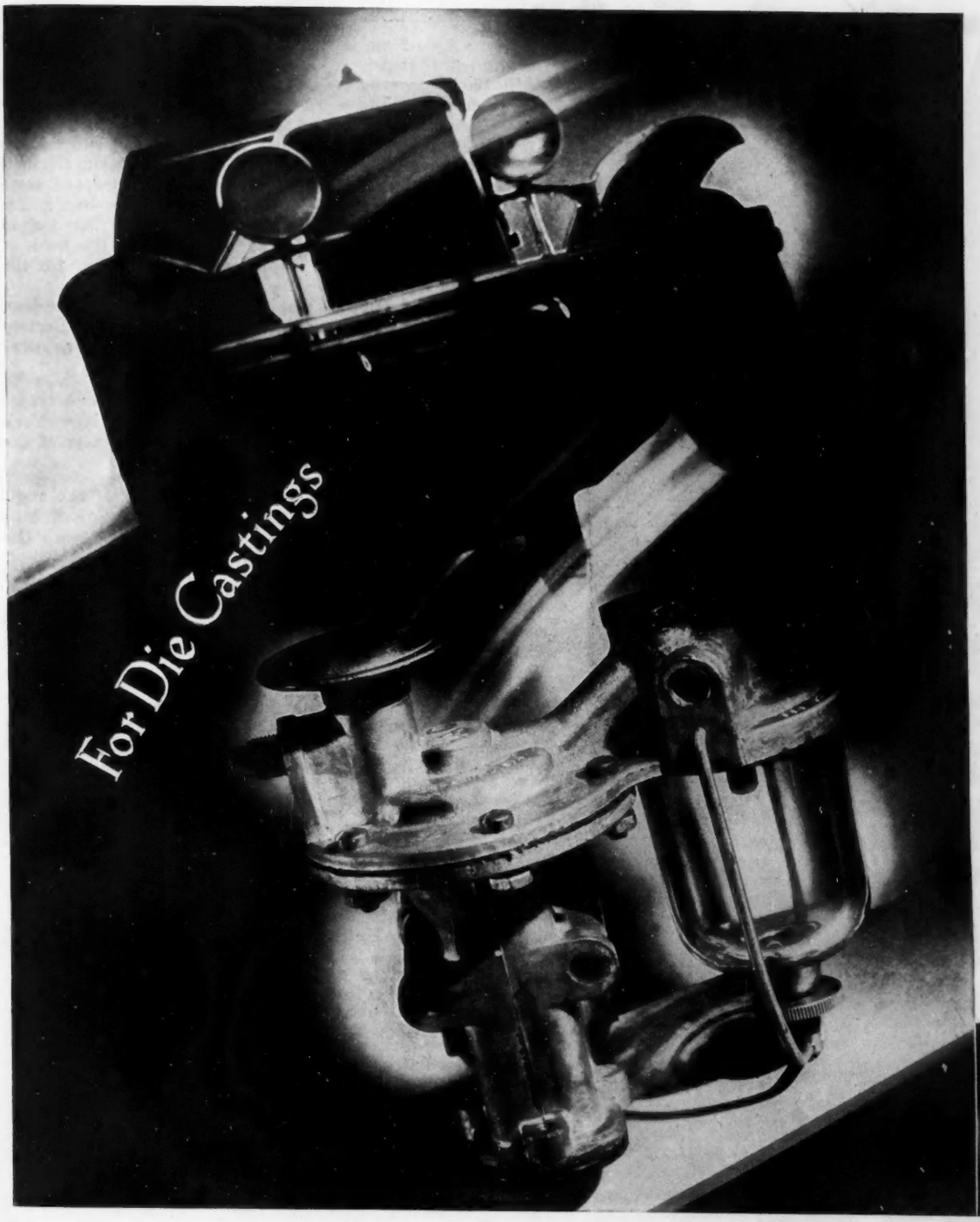
Theory of Evolution Applies to Radiator Shells of Automobiles. By Herbert Hosking. Published in *Automotive Industries*, Sept. 6, 1930, p. 328. [L-1]

The author of this paper contends that during the course of the automobile history the general tendencies in radiator shell and hood design of the Fiat, the Mercedes and the Minerva have influenced most of the passenger-cars in the American market.

This may be because the design of these cars has caught the popular fancy and they have sold well. Even designers of air-cooled cars have not availed themselves of the scope permitted them in design, but have striven to make their cars look like the most fashionable of the water-cooled cars.

The author points out that once again a crystallized style form is in danger of obviating the inventive ingenuity of the automobile designer, even if it is only in the case of what might be thought a small detail of the completed car.

HORSE HEAD *UNIFORM QUALITY* ZINC



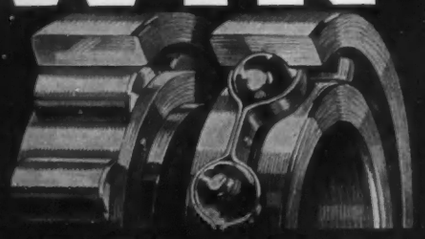
Fuel Pump die cast from an alloy of Horse Head—*uniform quality*—Zinc.

Consistent, uniform performance . . . meeting the needs for fuel supply under all operating conditions . . . made the fuel pump standard automotive equipment. ¶ Naturally the fuel pump manufacturer must be as certain of the uniform performance of the Zinc he uses in die casting the pump . . . Reliability, precision and economy of die castings all depend on the uniform quality of the metal. ¶ The maker of die castings who uses Horse Head—*uniform quality*—Zinc is certain.

THE NEW JERSEY ZINC COMPANY

160 FRONT STREET, NEW YORK CITY

Zinc Metal and Alloys ▪ *Rolled Zinc* ▪ *Zinc Pigments* ▪ *Sulphuric Acid* ▪ *Spiegeleisen*

TWIN

PRECISION

IN the past twenty years many standards have become flexible, and quality has become a variable thing . . . But, throughout this period NORMA-HOFFMANN Precision Bearings have continued to be the choice of those who measure value by service rendered, and who seek the lowest cost per bearing per year of useful bearing life.

"NORMA-HOFFMANN"
PRECISION BEARINGS

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD CONN., U.S.A.

Personal Notes of the Members

(*Continued from page* 625)

the capacity of metallurgical engineer and, later, as chief metallurgical engineer.

In 1909, after being graduated from the University of Michigan, Mr. Watson was appointed assistant chief chemist of the Texas Portland Cement Co., of Dallas, Texas. In 1910, however, he returned to Detroit and entered the service of the Packard Motor Car Co. as assistant chemist. Three years later he took the post of engineer of tests for the Sheldon Axle & Spring Co., at Wilkes-Barre, Pa. He associated himself with the Hupp Motor Car Co. in 1914 and during the World War was active in the work of building tanks, which the Hupp company was doing for the Government.

Before his election to the presidency of the American Society for Steel Treating, Mr. Watson served that Society for two years as treasurer and, in the last year, as vice-president.

Henry L. Abbott, former assistant secretary and treasurer of the Osborn Development Co., Inc., of New York City, is now secretary and chief mechanical engineer of the Colprovia Roads, Inc., also of New York City.

George C. Appel recently became a member of the engineering department of the Globe-Union Mfg. Co. of Milwaukee. He was formerly an electrical engineer with the Harley-Davidson Motor Co., of the same city.

Carroll M. Aument has been elected president of the Flying Dutchman Aircraft Corp., of New York City. His previous connection was with the Fokker Aircraft Corp. of America, in Hasbrouck Heights, N. J., where he was factory manager.

Kelvin C. Backhouse, having relinquished his post as assistant chief engineer for the Godward Gas Generator Co., Inc., of New York City, is now employed as superintendent of the H. A. Smith Machine Co., of Hopewell, N. J.

Clay Anderson, former commercial-car and truck representative of the Dodge Brothers Corp., of New York City, is now a special factory representative of the French Battery Co., of Chicago, with headquarters in New York City.

Carl Abell who has been engaged in sales engineering with the Hall-Scott Motor Car Co., of Berkeley, Calif., is now employed by United Patents, Ltd., patent brokers of San Francisco, as sales engineer.

G. A. Christopher, former sales engineer for the Sky Specialties Corp., of Detroit, is now sales manager for the Detroit Oil Products Co., also of Detroit.

Walter E. Battles, who recently resigned as production manager of the Ward LaFrance Truck Corp., of Elmira, N. Y., is now employed by the Pennsylvania Power & Light Co., of Allentown, Pa., as mechanical engineer.

George C. Claridge, lately service specialist with the General Motors Export Co. at Hendon, London, England, is now serving the United Africa Co., Ltd., of Kingsway, London.

W. Frank Crawford, who has been serving the Marmon Motor Car. Co., of Indianapolis, for the last eight months, in the records experimental department, is now planning to resume his studies at the Rose Polytechnic Institute, where he will study mechanical engineering.

W. W. Cunningham has given up his position as draftsman with the Consolidated Aircraft Corp., of Buffalo, and is now connected with the Glenn L. Martin Co., of Baltimore.

Austin W. Deyo, former general manager of the Deyo Oil Co., Inc., of Binghamton, N. Y., is now connected with the Colonial Beacon Oil Co., Inc., of Rochester, N. Y.

(*Concluded on next left-hand page*)

MoToVoX

OUT IN FRONT WHERE THE WARNING SIGNAL BELONGS

. . . *Eloquent Cars* . . .

TIME was when a man with a red flag was required by law to pace ahead of the "horseless buggy," warning the populace of its approach. And for many years later the matter of proper warning signals received little attention. Only recently have designers realized that the modern car with its high speed requires an *eloquent* voice to cope with present-day traffic.

One result of this realization is the Motovox sound-producing unit, developed by the makers of the famous Moto Meter. This disk-shaped warning signal is already being widely sold as an accessory. It mounts out in front on the crossbar—where the warning signal logically belongs, where its compelling sound, unmuffled by radiator, shutters and fan slipstream, is most effective.

Your product can be smarter and safer if Motovox is incorporated into the design as *standard equipment*. You are cordially invited to consult us about Motovox. It costs you nothing to get all the facts—and it will be worth your while.

THE MODERN MOTOR HORN UNIT

At the left and right is pictured the Motovox sound-producing unit. Note how compact and sturdy it is, how well and closely constructed. This is the voice of the modern car—a warning signal adapted to become an integral part of automobile design. Its ornamental possibilities are fascinating, because it is meant for the outside of the car. Here at last is an automobile sound unit that fulfills every requirement. Above is a Motovox design worked out by Moto Meter engineers. These experts stand ready to cooperate with you at any time in the solution of your problems.

MOTO METER

GAUGE & EQUIPMENT CORPORATION

TOLEDO, OHIO NEW YORK, U. S. A.

LA CROSSE, WIS.

Factories at Toledo La Crosse Canada England France Germany Australia

Wanted Automobile Engineer

Recent expansion of engineering facilities by large manufacturer of moderate priced automotive vehicles in the Middle West requires the services of Experienced Engineering Executive. The responsibilities of Chassis Design, Drafting, Research, Development and Experimental Departments will be assumed by the engineer of long and varied experience who meets the requirements of this assignment.

A well equipped laboratory with excellent and experienced personnel is available to assist the man selected for this work. A splendid opportunity is open to the experienced engineer who may desire to make a new connection.

The salary is dependent upon the man. In replying give a detailed outline of your education and experience, and salary expected. Letters will be held strictly confidential if you so desire.

Address Replies
Box 100
S.A.E. JOURNAL
29 West 39th St.
New York

Send for This
NEW CATALOG

The Moltrup Steel Products Catalog No. 2 is a complete directory of information on Cold Drawn, Milled and Ground Specialties. It should be in the file of every executive responsible for the purchase of material of this character. *Ask us to mail your copy.*

We Specialize on the following Steel Products

Cold Drawn Steel in Rounds, Squares, Hexagons, Flats and Special Shapes.

Turned and Polished Shafting.

Free Cutting Screw Stock.

Special Polished Rod.

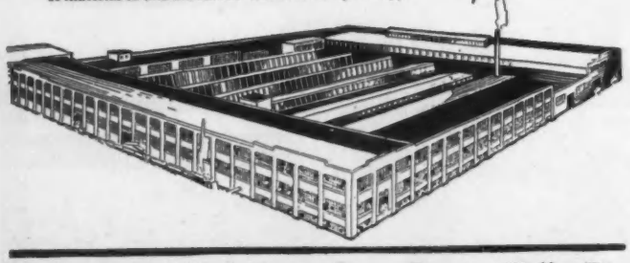
Machine Keys.

Woodruff Keys.

Machine Racks.

Flattened Steel Foundry Pattern Plates.

Ground Steel Plates for Various Uses.



Moltrup Steel Products Co., Beaver Falls, Pa.

Sales Offices—New York, Woolworth Bldg.; Boston, 60 Boylston St.; Buffalo, 303 White Bldg.; Portland, Oregon, 1207 Beach Blvd.; Philadelphia, Pa., 1600 Broad Bldg. Sales Agents—Central Steel & Wire Co., Chicago and Detroit; R. H. Cushman Company, Cleveland; S. L. Morrow & Co., 324 National Bank of Commerce Bldg., Norfolk, Va.

Personal Notes of the Members
Concluded

Sidney W. Farnsworth, former vice-president and secretary of the Handy Governor Corp., of Detroit, is now a member and vice-president of the investment securities firm of Case Pomeroy & Co., of New York City.

F. J. Foster recently assumed the duties of experimental engineer with the Muncie Products Division of the General Motors Corp., at Muncie, Ind. He previously served the Lycoming Mfg. Co., of Williamsport, Pa., as engineering representative for production.

Henri A. Franchimont, until recently areonautic engineer in charge of mathematical design for the Fairchild Airplane Mfg. Co., of Farmingdale, N. Y., is now connected with the Pan American Airways, of New York City, in the capacity of aircraft engineer.

Lawrence R. Gartung is now employed as a tool maker for the Chevrolet Motor Co., of Bay City, Mich. He previously studied at the General Motors Institute of Technology in Flint, Mich.

Carl S. Gove, former superintendent of service for the Massachusetts Motor Car Co. at Allston, Mass., is now the proprietor of an automobile service station at Brookline, Mass.

C. F. Grimes recently became president of the Main Auto Service Co., of St. Louis. He was formerly superintendent of assembly for the General Motors Co. of Brazil, at Sao Paulo, Brazil.

Conrad O. Hersam, formerly president of Hersam & Sherwood, Inc., consulting, designing and industrial engineers, of Germantown, Philadelphia, will maintain offices in Philadelphia, and act as consulting engineer on sheet-metal products and production-tool problems.

Donald de Lackner, a former New York University student, is now employed by the Sikorsky Aviation Corp., of Bridgeport, Conn., as a construction engineer's assistant.

John C. Leslie, who has been serving the Pan-American Airways, Inc., of Miami, Fla., as maintenance engineer, has been promoted to the position of divisional engineer for that company, with headquarters at Para (Belem), Brazil, South America.

Louis G. Meister, formerly vice-president and general manager of the Cleveland branch of the Curtiss-Wright Flying Service, is now in charge of military sales for the Verville Aircraft Co., of Detroit.

C. R. Paton has relinquished his position as a member of the research department of the Studebaker Corp., of South Bend, Ind., and accepted a post in experimental engineering with the Packard Motor Car Co., of Detroit.

Curt H. M. Patzig, until recently a mechanical draftsman for the Fokker Aircraft Corp. of America, at Hasbrouck Heights, N. J., is now employed in the engineering department of the International Motor Co., Inc., of Plainfield, N. J.

J. Otto Scherer has severed his connection as chief engineer with the Junkers Corp. of America, of New York City, and entered the independent field as a consulting engineer in Detroit.

Mich. E. Toepel, former electrical engineer for the Robert Bosch Magneto Co., of Long Island City, N. Y., is now employed in a similar capacity by the E. A. Laboratories, Inc., of Brooklyn, N. Y.

H. R. Voorhees is now a designer for the Hupp Motor Car Co., of Detroit. His prior connection was with the Verville Aircraft Co., of Detroit, in the same capacity.